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AUTOMATIC MACHINE FOR BUILDING BICYCLE WHEELS

IN this month's cover illustration, an operator inserts a partially built cycle wheel into an automatic machine that will tension the spokes under servo control to build a true-running wheel. Electrically driven spanners around the circumference are controlled by command signals from the scanning arm above the wheel. A description of the machine is given in the article on p. 554

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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CO-OPERATION WITH EUROPE

THE role of scientists and engineers is in many ways a privileged one. For while political, military and economic rivalries tend to isolate nations, science as a pursuit of the intellect knows no frontiers. Engineers and scientists meet informally, exchange ideas, deal in universals. Their common tongue is no less widely accepted than was Latin centuries ago, and their professional search for truth helps to create a common basis for understanding and tolerance. In this way, at the scientific level, a pattern of unity and strength is introduced into society. If no other factors prevailed, whole-hearted scientific and technological co-operation on a world-wide basis would be universally desirable.

Once material achievements become manifest, unfortunately, the seeds of discord are also sown. Military developments affect national security, industrial processes give rise to commercial and economic rivalries, and national prestige increasingly influences foreign policy. For this reason, the collaboration sponsored by United Nations technical agencies, for example, tends to be of a quite general nature. The West, with common military interests, can enter into a more substantial co-operative programme, while smaller regional groups with similar environments and both military and economic interests can find a still higher common factor. In recent years, NATO, O.E.E.C., the Council of Europe and The Six have all accepted different roles in European scientific co-operation.

In fundamental research, the advantages are easy to recognize. No single country in Western Europe could really have afforded to set aside £20 million and a staff of 400 solely for academic studies with two particle accelerators. It was possible to achieve this in Geneva only because 12 European countries were prepared to join forces in establishing CERN, each nation contributing a sum proportional to its national income, each supplying a number of the staff, and each being given the full opportunities of a vigorous research centre. This is an achievement that could well be emulated in space research, radio astronomy and many other subjects.

In the applied field, co-operation is more difficult to achieve, but the need is even greater. Industries are increasingly demanding larger and more complex research programmes and installations, huge capitalization, longer production runs, and hence, if they are to be justified, larger markets. More products are competing to meet the present demand, profit margins are being reduced, and the rate of obsolescence and demand for new products is accelerating. Technological overheads are likely to rise increasingly beyond the reach of individual firms and even countries, and, in addition, the excessive duplication of effort involved will represent a waste of valuable manpower and other scientific resources. The need for integration of scientific resources is, in fact, becoming as important as that of economic resources. This does not imply an idealistic sharing of commercial secrets. Competition must continue, but competition of a more intelligent type.

An attempt to rationalize the European applied scientific effort has already met with a modest degree of success. It began with O.E.E.C. encouraging self-financed co-operative projects in the technical field. In the study of the corrosion of ships' hulls, for example, standardization of tests was arranged and testing facilities were shared, so that Norwegian shipbuilders using British anti-fouling paint could use warm Italian harbours and so carry out more-worthwhile investigations. Again, investigations on metal fatigue were successfully made with tests on 43 million pieces of metal in nine different national laboratories in Europe.

More recently, O.E.E.C. (now O.E.C.D.) has attempted to elucidate the part played by education in the economy and has demonstrated the need to utilize scarce resources of skilled manpower as a critical item in national investment. An annual review procedure assists countries to assess their own educational problems and reforms against the accumulated experience of the policies of other countries. Among the interesting studies and discussions that have taken place are the methods and curricula of mathematics and chemistry teaching and the role of television in schools.

The Conference of Engineering Societies of Western

Europe and the United States of America, EUSEC, has exerted a beneficial influence in the field of engineering technology since its inauguration by the British engineering institutions in 1948. It has enabled the member societies, now drawn from 16 nations, to discuss, through meetings attended by their presidents and permanent secretaries, matters of common interest and concern to the advancement of engineering science. EUSEC has convened a number of conferences on the education and training of professional engineers and, with support from the O.E.E.C. and the Ford Foundation, has conducted a valuable comparative survey of the methods of engineering education and training practised by the countries of Western Europe, including Great Britain, and by the United States.

In parallel with these efforts, important steps are now being taken by NATO to increase the effectiveness of science in the West. The Office of the NATO Science Adviser in Paris has launched a large fellowship scheme of about £1 million a year. It acts, in effect, as an international science foundation, facilitating the movement of graduates and senior researchers so that they may continue their studies abroad. It also has given its support to summer schools on advanced scientific subjects, has provided a research-grant fund to facilitate additional fundamental research, and has made recommendations that include the provision of an international clearing house to expedite the transfer of research equipment.

Probably its most important proposal is the establishment of an international institute of science and technology. In the United States, the Massachusetts and California Institutes of Technology have had a great influence on the development of science and technology. Around them, industries have been established that show surprising vitality in the manufacture of highly sophisticated equipment. It is doubtful whether any single European country could find the resources in manpower and money to proceed on its own, but Western Europe as a whole could easily muster the required talent and equipment. Such an institute, it is held, could comprise one or more centres, granting their own degrees and concentrating on work at postgraduate and advanced level. Whether this particular proposal is implemented or not, the need for new educational institutions is essential in a Europe that is still producing only half the number of engineers required.

The development of scientific and technological co-operation between Britain and Europe has clearly been influenced already by the successive measures of economic integration taken by The Six. First, the European Coal and Steel Community in 1951 created a unified market producing one-fifth of the world's crude steel and one-sixth of its hard coal, and initiated a combined research programme. Then, following the Messina Conference in 1955, the Treaty of Rome gave birth to Euratom and the Common Market.

Euratom has already established its own research centre and helped to rationalize the research activities of its members. Now its proposals to establish a European University in Florence have been approved. The Common Market agreement is more far-reaching, for over a period of years it is intended, partly by merging the research, development and production activities of industry, to transform the economies of these countries, which have an industrial population equal to that of the United States, so that one vast market would be created capable of supporting large-scale industry, employing the most modern production techniques, lowering costs, improving living standards, and under-selling.

There is little doubt but that the decision whether we and the Outer Seven eventually join The Six will determine to an important degree and for many years to come the form of development of science and technology in Great Britain.

POWER AND CONSENT

THE Central Electricity Generating Board want to build two coal-fired 2000 MW power stations in Yorkshire and an oil-fired 2000 MW station at Fawley on Southampton Water.

The Yorkshire sites are on the River Aire, one at Eggborough and the other at Ferrybridge. The local authorities have approved both stations, and the Minister of Power has agreed on Ferrybridge. It will be started next month, next door to the existing Ferrybridge A and B stations. There will be four 500 MW turbogenerators and four 3450000 lb steam/h boilers. Steam conditions will be 2300 lb/in.^{2} at 1050° F, with reheat to 1050° F. The first set will start working in 1965, and the station will be completed in 1967.

The Fawley site is on reclaimed land and saltings. If it is approved, the C.E.G.B. would defer application to build a nuclear power station at Hamstead, Isle of Wight. The Fawley station would be connected to the national Grid by an overhead 400 kV line running north and by undersea cable to a line on the opposite side of Southampton Water.

SCREW-THREAD PRACTICE

AN inquiry has revealed that a substantial majority of the members of the British Electrical and Allied Manufacturers Association feel that when the time comes to make a change in screw-thread practice it should be to the I.S.O. metric thread. While there is no indication as yet that Whitworth and B.A. threads are less generally acceptable at home and oversea than in the past, it must be foreseen that, if and when the I.S.O. recommendations are adopted, Whitworth and B.A. threads will become obsolescent.

The majority view in the B.E.A.M.A. was evident when the membership was taken as a whole and when grouped as 'heavy plant', 'industrial equipment', and 'light engineering and domestic equipment'.

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PIONEERS OF BINARY CODING

In the past 15 years, digital computers and associated devices have exploited many binary-code properties. A similar expansion of digital ideas took place during the early days of telegraph development, largely based on the idea of using a yes–no method for communication. This, the 0 and 1 of the binary system, seems to have been understood intuitively from the earliest days of civilization. The article discusses three of the codes that are important in modern digital machinery, with some notes on their inventors. The author is at the Manchester College of Science and Technology.

F. G. HEATH, B.SC., ASSOCIATE MEMBER

It is possible to arrange blocks of binary digits (words) into many codes or alphabets, each with properties that are important for some application. The three principal types of code are shown in Table 1, for three-digit words in each case. Table 1a is, of course, the binary-number progression that corresponds exactly with the use of numbers up to 9 in ordinary arithmetic and is the form in which numbers will be found in many digital computers. Digital–analogue conversion is a natural process with numbers in this form.

One of the troubles with the binary-number progression of Table 1a is that it does not lend itself to the simple construction of commutator-type position pick-offs. If a row of brushes is situated along the boundary between 011 and 100 on a code wheel modelled after Table 1a, any of the eight combinations of 0 and 1 might be read, depending on slight errors of mechanical alignment.

Table 1. Three types of binary code

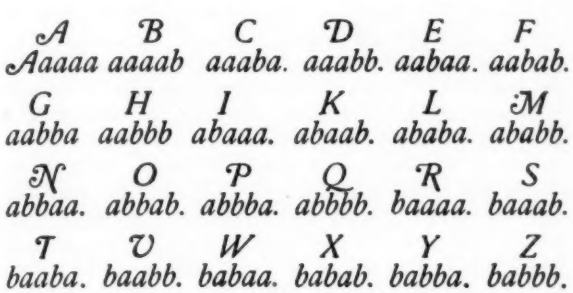
primary number	(a) Simple binary code	(b) Cyclic-permuted (c.p.) or Gray code	(c) Chain code
0	000	000	000
1	001	001	001
2	010	011	011
3	011	010	111
4	100	110	110
5	101	111	101
6	110	101	010
7	111	100	100
8	repeats	repeats	repeats

This difficulty may be overcome by using auxiliary methods and equipment or by replacing the sequences of Table 1a by those of Table 1b, the cyclic-permuted (c.p.) or Gray code. The main property of this progression is that only one digit changes with each single advance of position, so that any of the brushes will always read one or other of the immediately adjacent patterns. Consequently, a c.p. code wheel never generates wild patterns, and the accuracy of output information depends only on the accuracy of construction. C.P. coding is simply related to binary, as can be seen by careful inspection of Tables 1a and 1b, and has the property of less total commutation per revolution than any other progression.

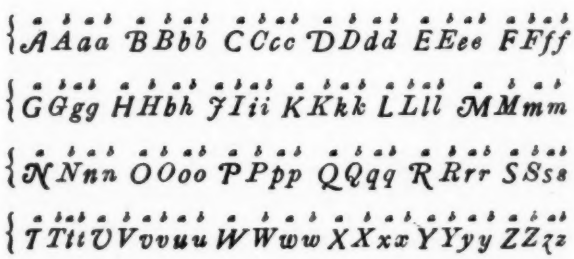
Table 1c shows a typical complete chain code. The basic property here is that the last two digits of each pattern are the first two of the next. Consequently, the sequences of Table 1c may be produced by selecting three adjacent digits at a time from a single 8-digit code, 00011101, which may be closed on itself in a ring or chain. Besides this property, which is useful in pick-offs, chain codes may be used in error-correction processes and random-noise generators.

Sir Francis Bacon

It is quite certain that Sir Francis Bacon discovered the use of the binary sequences as a cipher. He described it completely in 'De augmentibus scientiarum', written in 1623. Fig. 1a shows Bacon's suggested code for the


A B C D E F
aaaaa aaaab aaaba. aaabb. aabaa. aabab.
G H I K L M
aabba aabbb abaaa. abaab. ababa. ababb.
N O P Q R S
abbaa. abbab. abbba. abbbb. baaaa. baaab.
T U W X Y Z
baaba. baabb. babaa. babab. babba. babbb.

a



b

1 *Sir Francis Bacon's cipher*
a 'bi-literarie' alphabet
b 'bi-formed' alphabet

alphabet (only 24 letters at that time), which is the simple binary sequence if *a* is put equal to 0 and *b* to 1.

The first step is to take the secret message and write it out as a series of *a*s and *b*s, a process that multiplies its length by five. An innocent message is now chosen, and this message carries the ciphered passage by means of the biformed alphabet shown in Fig. 1b. Two type founts are used, and each letter of the innocent message is chosen as *a* or *b*, depending on the ciphered series.

Bacon was an expert on ciphers and claims to have invented this code in his youth. Certainly there is no evidence that anyone preceded him.

Early telegraph history

There is indirect evidence that Gauss applied Bacon's code to a telegraph system around 1833, possibly in conjunction with Weber. This early idea did not dissuade other inventors, and in the years that followed some extraordinary systems were proposed and patented. As soon as multiplex working was developed, however, only a code where each letter occupied the same length of time was practical, and the various codes proposed began to resemble the columns of Fig. 1 (but with more digits in each row).

The Gray code is named after Elisha Gray, who is best known for filing his unsuccessful caveat only a few hours after Bell had patented the telephone. He made many more discoveries. It is not easy to discover when Gray first used this code, but he won a Grande Médaille at the 1878 Exposition Universelle in Paris, with no reasons given for the award.

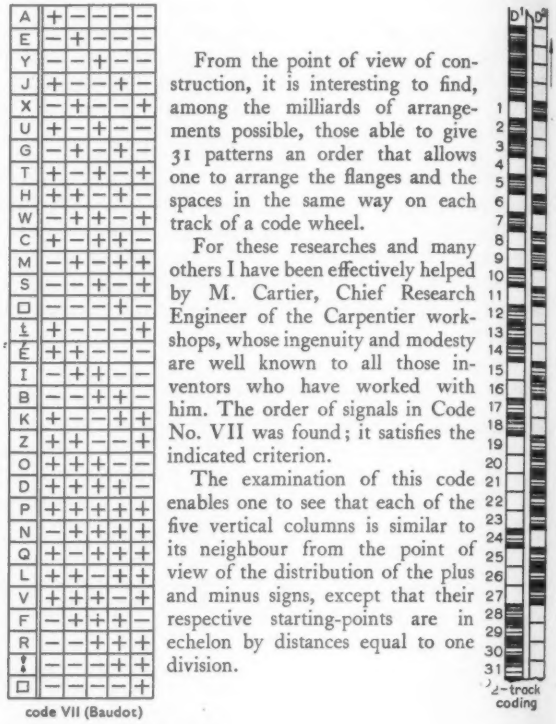
At this same exhibition, Baudot, the great man of the French telegraph service after whom the baud is named, also won a Grande Médaille. Further, he was made a Chevalier of the Légion d'Honneur, specifically for his design of a multiplex-printing telegraph equipment, which was exhibited and stated to be working perfectly on the Paris–Bordeaux link. This equipment, in fact, used a code disc with commutator segments arranged on five tracks in the pattern of a c.p. code, and one article states that Baudot chose this code for minimum commutation (and therefore minimum wear). It is clear, therefore, that Baudot understood and used a c.p. code in 1878.

The technical justification for using this code is no longer valid at a time when it is possible to make instrument-type commutators with very good life properties, but in Baudot's era materials were more limited and an idea that reduced 62 commutations of the binary code to 32 (c.p.) theoretically doubled the life of the code wheels. Since the system worked with a similar code at transmitter and receiver, no conversion problems existed.

Chain-code telegraph

The honours Baudot won in 1879 were at the beginning of his career (he was 34 at the time). He carried on with his work and made many improvements. In a textbook on printing telegraphs, one reads that there is hardly one of the components in a modern telegraph system that has not been profoundly influenced by Baudot.

In 1889, Baudot again showed telegraph equipment, winning a Grand Prix. He wrote a comprehensive paper describing the design details of this equipment, stated that it was in operation in 1882–83, and discussed the



2 *Baudot's chain code*

From the point of view of construction, it is interesting to find, among the milliards of arrangements possible, those able to give 31 patterns an order that allows one to arrange the flanges and the spaces in the same way on each track of a code wheel.

For these researches and many others I have been effectively helped by M. Cartier, Chief Research Engineer of the Carpentier workshops, whose ingenuity and modesty are well known to all those inventors who have worked with him. The order of signals in Code No. VII was found; it satisfies the indicated criterion.

The examination of this code enables one to see that each of the five vertical columns is similar to its neighbour from the point of view of the distribution of the plus and minus signs, except that their respective starting-points are in echelon by distances equal to one division.

chain code that it used. Fig. 2 is a synthetic diagram, produced from two of the illustrations in Baudot's 1895 paper, with a translation of the appropriate passage.

The way that Baudot and Cartier developed the chain code may be summarized as follows: 31 individual binary patterns are needed (ignoring 00000), with five digits in each pattern. These can be put in any order whatsoever for telegraph work. Is there an order for the patterns such that the digit sequences running down the columns are identical but displaced in all five columns? If so, the five similar but displaced columns may be replaced by one track, using five brushes suitably placed round this single track. Fig. 2 shows on the left the arrangement of the five-digit words that gives the desired behaviour of the columns, and on the right Baudot's code, which actually had two tracks, the chain code and its inverse.

The invention of the telephone probably stopped any large-scale public expansion of the telegraph, which retained its value in applications where the output was wanted in printed form. Equipment was developed that gave excellent service over telephone lines, and the heavy capital cost of such systems precluded new ideas that promised only marginal improvements.

The digital computer

All early electronic digital computers used basic circuits that registered 0 and 1 only, because of the poor tolerances available on valve parameters. Many specialized codes were used, as well as the three described.

The main new idea, which does not seem to have occurred to any of the historical workers, is that of error correction, using redundant digits. Baudot might reasonably have been expected to mention it, since his later system could have been made to correct errors directly, but no hint is present in his published work.

It is quite likely that a data link that is printing normal language and being read by a shrewd human being has enough redundancy for most practical purposes, whereas a string of 0s and 1s being read by a fairly naïve machine needs safeguards.

Summary

Binary codes have an established place in electrical engineering, and the future may well bring applications for ternary and higher-order codes. Sir Francis Bacon summed up well, in 1623, when he wrote 'Neither is it a small matter these cypher-characters have, and may perform: for by this art a way is opened, whereby a man may express and signify the intentions of his mind at any distance of place.'

DIPLOMA IN TECHNOLOGY

THE recently published Report of the National Council for Technological Awards covers the period from April 1960 to March 1961. The report states that nearly 5000 students were taking courses in the Diploma in Technology, compared with 3800 a year before, and that nearly 1770 students (including 63 women) had enrolled in first-year courses, compared with 1500 (40 women) in the previous year.

During the year under review, 309 students gained Diplomas in Technology, bringing the total number of Diplomas awarded to over 470, and 25 applications for registration as candidates for Membership of the College of Technologists were received. About 83% of the engineering students and 56% of the students of technologies other than engineering were based on industry.

Recognition of Diploma

The holder of a Diploma is recognized by the Burnham Technical Committee as eligible for the graduate addition to his salary. The Diploma is accepted as a qualification for entry to the Scientific Civil Service on equal footing with a university degree. The Committee of Vice-Chancellors and Principals have recommended universities in the United Kingdom to treat Diploma holders on the same footing as university graduates when considering applications to enter a course leading to a higher degree. The majority of professional institutions exempt Diploma holders from taking the whole of the institutions' own examinations for graduate membership.

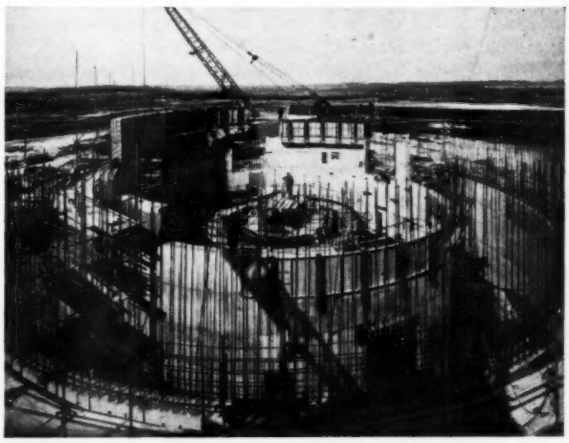
Nature of course

The Nuffield Foundation is supporting two investigations into the type, nature and scope of courses leading to the Diploma. Birmingham College of Advanced Technology has recently received a grant of £6700 from the Nuffield Foundation to investigate the spacing of industrial and college training in courses for the Diploma at colleges of advanced technology. A grant of £15000 has also been made by the Nuffield Foundation to Brunel College of Technology to establish a small research unit to conduct social psychological research. The major part of the project is a study of the process of sandwich-course education at Brunel College.

DRAGON PROJECT, WINFRITH

THE European Nuclear Energy Agency of the Organisation for European Economic Co-operation has published its 2nd Annual Report to its Steering Committee on the Dragon High Temperature Reactor Project at Winfrith. The principal aims of the Dragon project, set up by 12 European nations including the United Kingdom, are to design, build and operate a 20MW (thermal) high-temperature gas-cooled reactor experiment, and to explore the practical possibilities of this type of reactor.

The report covers the period from the 1st April 1960 to 31st March 1961. Among the highlights noted are the rapid progress of construction work, the finalizing of a great deal of detailed technical design, the large numbers of research and development problems being studied, and an agreement in principle that the United Kingdom Atomic Energy Authority will supply the enriched uranium for the first fuel charge. Although the design of the reactor has been reconsidered, it has not been necessary to make any fundamental changes to the design as a whole, but improvements have been made to particular items.



Dragon reactor building under construction

An electrical engineering review

TRANSDUCERS IN PROCESS CONTROL

621.317.39:621-52

'Transducer' is a term whose meaning varies according to its application. In this article, 'transducer' is defined as used in process control, and its more common applications are indicated. Types of pressure transducer are discussed, and an outline is given of the requirements in the process field. The author is with Constructors John Brown Ltd.

A. B. TAVENDALE, B.SC.(ENG.), GRADUATE

ALTHOUGH a transducer is a device that converts signals from one set of units into other units, the process-control field has tended to classify transducers as devices that convert measurements from other units into electrical quantities, and then classify convertors as devices that convert electrical signals into other quantities. This narrowing of the definitions stems from the fact that a large number of the process measuring and control instruments are themselves transducers of one form or another. With the general introduction of reliable electronic equipment in this field, the transducer has become the link between existing measuring techniques and electrical signals, and the convertor the device that converts the electrical control signal to either a pneumatic or a hydraulic one used to operate the regulating device, generally a control valve.

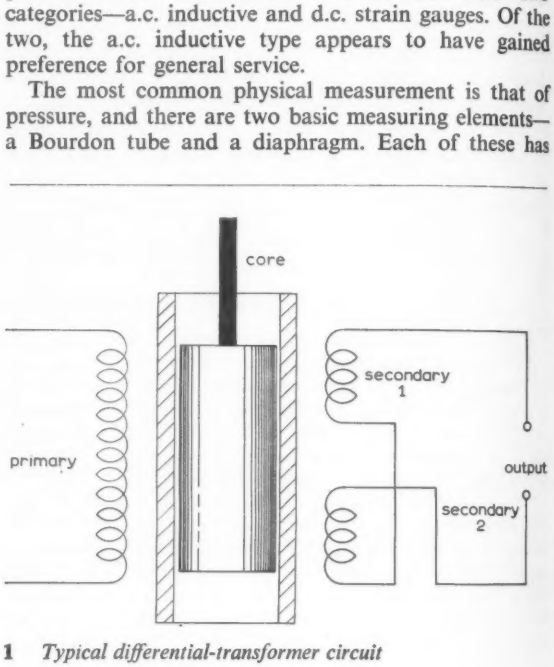
The most common parameters to be measured in the process field are pressure, temperature, level and flow. Others, such as load, velocity and displacement, are also becoming more widely used. In the first group, the temperature-measuring devices are not transducers by accepted definition. The thermocouple has long been used for temperature measurement, as has the resistance thermometer; and commercial indicating and recording instruments for use with these thermometers have been available for at least 30 years. It is apparent, therefore, that the name 'transducer' applies only to equipment developed in the last decade or so and not to long-established units, even though they do enter into the classification.

Measurement methods

In the majority of measurements, the measured signal is obtained from a physical displacement of some form—displacement of a diaphragm or Bourdon tube in the pressure field, movement of a float for level measurement, etc.—and transducers utilize these physical movements to create the electrical measurement signal.

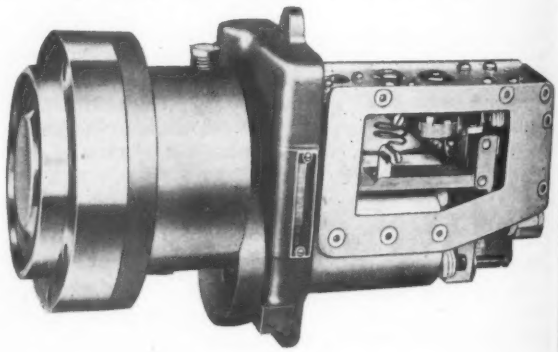
There are a number of ways of translating physical movements into electrical quantities, but, when accurate measurement is required, it is preferred that the translating medium should not impede or load the detecting device. Hence the techniques chosen for transducers in process-control instruments tend to fall into two categories—a.c. inductive and d.c. strain gauges. Of the two, the a.c. inductive type appears to have gained preference for general service.

The most common physical measurement is that of pressure, and there are two basic measuring elements—a Bourdon tube and a diaphragm. Each of these has specific advantages over certain pressure ranges, but either can be used over the greater part of the pressure scale encountered in process measurement. The methods adopted in transducers for pressure measurement will be briefly described.



1 *Typical differential-transformer circuit*

2 *Diaphragm pressure transducer (cover removed)*



Bourdon-tube pressure transducer

The displacement of the free end of a Bourdon tube is proportional to the internal pressure applied. To convert this movement to an electrical signal, a differential transformer is commonly used. A differential transformer, which is an a.c. device, consists of a winding arrangement in which the couplings between the single primary and the two secondary windings are identical when the core is in mid-position (Fig. 1). At this setting, and with the two secondaries connected in opposition, there is zero output.

As the core is moved away from centre, the coupling factors of the secondaries change, and one will have a higher voltage developed across it. This unbalance voltage is a measure of the displacement. The outputs of differential transformers are normally rated in terms of unbalance-voltage signal per 0·001 in. core displacement at a given energizing supply voltage.

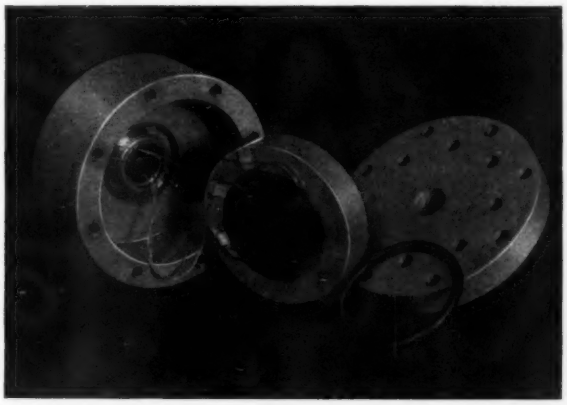
Diaphragm pressure transducer

In general, the movement of a diaphragm is considerably less than that of a Bourdon tube, so the differential-transformer technique has to be modified when it is applied directly to measuring diaphragm movement.

Two techniques are possible:

(i) Amplify the mechanical motion of the diaphragm
(ii) Use a more sensitive differential transformer.

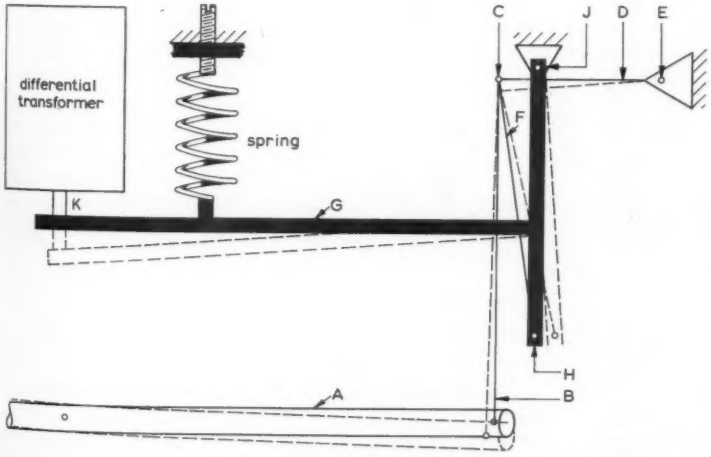
Both these solutions have been adopted in practice, and Fig. 2 shows an instrument in which the mechanical motion has been amplified to operate a conventional differential transformer. The operation is shown diagrammatically in Fig. 3. A force from the measuring element causes a small motion of the end of lever A. This motion is transmitted through the linkage and operates on the core of the differential transformer at point K. A calibration spring exerts a force on lever G and is the zero adjustment of the instrument. The multiplication ratio is a function of the distance between point K and pivot J as compared with the distance between pivot C and pivot J. The ratio can be varied by moving pivot C. Thus adjustments are provided for both range and zero settings.



4 *Four-element foil strain gauge mounted on diaphragm of pressure transducer*

The second approach to this problem is a much simpler mechanical one: instead of a core moving through two balanced windings, the diaphragm forms the moving core. Two arms of a bridge circuit are formed by the two windings, whose inductances change differentially when the air-gap, caused by a movement of the diaphragm, alters. The other arms of the bridge are formed by two resistors. In practice, such a transducer is operated from a 400c/s oscillator, giving an open-circuit output of 50mV for an input of 1V. Transducers such as these were developed originally for aircraft service, and weight and size were kept to a minimum. The zero and range are set during manufacture and cannot be altered in the field.

Strain gauges are also used in diaphragm-type pressure transducers, and a typical design is shown in Fig. 4. The diaphragm is mounted in a cylindrical housing, and the sensing device is a 4-element foil strain gauge, bonded to the rear surface of the diaphragm. The input to the strain-gauge bridge can be either alternating or direct current, and open-circuit outputs of about 2mV for



3 *Diagram of mechanical linkage operating a differential transformer in a diaphragm pressure transducer*

B and F motion link pivoted about C
D radius link
E reference pivot
H motion-transfer pivot

an input of 1V are obtained. The zero and range are not adjustable in the field.

Types available

Table 1 summarizes the main features of three types and shows clearly the difference between a process transducer and other transducers developed originally for other service but capable of being used in the process field.

These examples do not cover the whole range of adopt a standard transducer unit that can be coupled to any of their range of measuring elements.

Differential transformers are generally employed as open-loop measuring elements, in that the signal or unbalance voltage is a measure of the quantity being measured. The force-balance type of unit is in essence a closed-loop system, in which the restoring force, e.g. current, is a measure of the quantity. The main advantages of the force-balance system are that non-linearities in the characteristics of the measuring element are eliminated and the measurement signal is at a high

Table 1. Diaphragm pressure transducers

	nominal supply	output/1V input	weight	dimensions	ranges (in.H_2O)	adjustments
differential transformer	50c/s 110V	5mV	14lb	$9\frac{3}{4} \times 6\frac{1}{2} \times 5$in.	0– 40* 0– 200* 0–1000*	zero and range
differential transformer	400c/s to 10kc/s 10V r.m.s. per coil	50mV	5oz	$2 \times 1{\cdot}4 \times 1{\cdot}5$in.	0–5 to 0–2000 (fixed steps)	none
strain gauge	a.c. or d.c. 3–6V	2mV	2lb	$2\frac{3}{4} \times 3\frac{1}{2}$in. diameter	0–25 to 0–500 (fixed steps)	none

* continuously adjustable within these ranges

pressure transducers, and a recent market survey gave the following figures from an examination of 88 units commercially available: strain-gauge types, 49%; differential transformer types, 31%; force-balance types, 9%; directly coupled potentiometers, 8%. The remaining 3% were units for special applications.

Although the force-balance types comprise only 9% of the total, they are all produced by manufacturers of process-control instruments. The force-balance units usually transmit a d.c. signal proportional to the measured variable, and this signal is in the range 0–5 to 10–50mA. The general arrangement of such a design is shown in Fig. 5. Here a movement of the beam, as a result of a change of the input force, unbalances the detector circuit, causing the amplifier to alter its output to the magnet unit and thus tending to restore the beam to its original position. The input signal is thus represented by the current passing through the magnet. Range and zero adjustment are provided.

General requirements in process industry

From this brief discussion of pressure transducers, two main classifications appear—the small, fixed-range type, suitable for service where size and weight are limiting factors, and the larger industrial pattern designed to operate in a wide range of conditions and where physical size is of minor consequence. As the use of transducers expands in the process field, the requirements are crystallizing, and the apparent policy of present manufacturers of process instruments is to level. This does mean, however, that a high-gain amplifier is required in the loop.

Equipment for use in the process industries has to meet specific operational requirements and operate satisfactorily in arduous environmental conditions. It is generally accepted that all instruments shall be capable of infinite adjustment over the range span and that this adjustment can be carried out in the instrument workshops. This facility allows one type of instrument to be used in a number of differing measurements and hence reduces the variety of replacements and spares necessary.

Long-term stability and repeatability are of prime importance, as the life of process instruments is expected to be that of the process plant, which is at least ten years. This does not necessarily mean that the instruments are left untouched for this period, as most installations have a scheduled maintenance programme in which all equipment is checked at regular intervals and overhauled.

Environmental conditions

Frequently, the structure and mechanism of the transducer are subjected to such severe treatment that the design of the unit is greatly influenced by the environmental conditions it may be expected to meet. Ambient temperature may be high or low, severe atmospheric pollution from dust or plant vapour can occur, and if the instruments are mounted on the structure of the plant they are automatically used as footsteps.

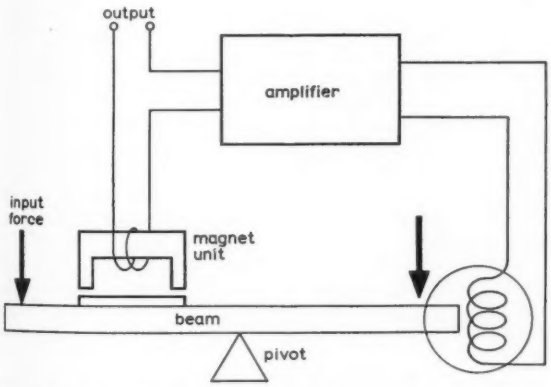
Additionally, in many installations the equipment

must meet flameproof requirements or be suitable for operation on an intrinsically safe circuit. These factors make it necessary to mount the measuring elements and transducers in waterproof and dust-tight cases of sufficient strength to allow them to bear the weight of a man without causing distortion in the mechanism.

The environmental conditions do not encourage the siting of electronic equipment with the transducers, especially if a flameproof installation is required. The signal from the transducer may frequently have to be transmitted over 200–300ft of cable, and it must not suffer degradation during transmission. It is becoming general practice to have pressurized control rooms in a hazardous installation, so that non-flameproof instrumentation can be used. This facility permits the installation, in the building, of any electronic amplifiers associated with site-mounted transducers.

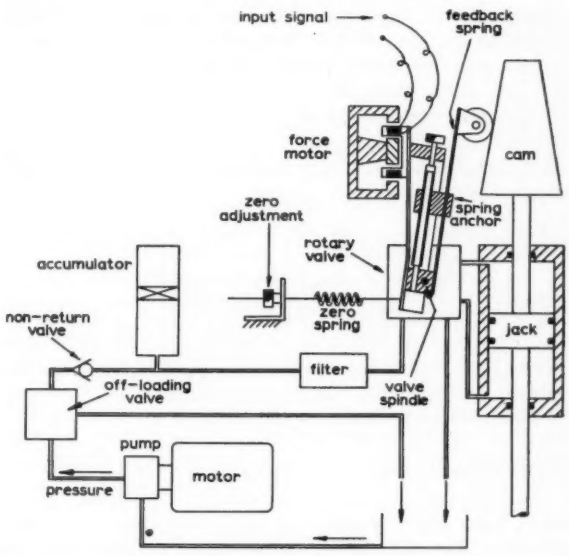
Control systems and regulating devices

As process plants become larger and more complex, the number of measurements and controls increases accordingly. The distance from the control room to the plant-limits also increases, and hence the signal-transmission distance demands electrical transmission if excessive lags are to be avoided. With low-level-signal transmission in a complex plant, the problem of induced signals owing to extraneous noise or other coupling is present, and the advantages of either an a.c. or a d.c. system must be considered. Although transducers are available giving either a.c. or d.c. signals, it has become accepted that control signals are direct current and vary between 0–5mA and at least 10–50mA.



5 *Typical circuit of a force-balance transducer*

The output from a controller is used to operate a regulating device, and in process work this in most cases is a control valve. These valves are normally fitted with pneumatically operated diaphragm motors, and an electro-pneumatic convertor is mounted on the valve to transform the low-level d.c. signal into a pneumatic one. However, this is only an interim method, as compressed air, as well as an electricity supply, are required for this control system. One solution to this problem is to employ electro-hydraulic actuators. These have been used in aircraft, but in process work proportioning action is necessary, and the unit must be capable of being mounted on most of the range of control-valve bodies available.



6 *Diagram of electro-hydraulic proportioning actuator*

A typical unit is shown in Fig. 6. The system consists of a power pack containing the control valve and a small electric motor driving a hydraulic pump. The supply of fluid to the jack is controlled by a rotary servo valve operated by a moving-coil electromagnetic force motor. The jack position is made proportional to the input signal by incorporating a spring feedback mechanism, which, when the jack has reached the desired position, balances the force generated in the moving coil of the force motor, thus maintaining the servo valve in its neutral position. To alter the stroke for the same input-signal range, the rate of the leaf spring is altered by moving the spring anchor point. As a safeguard against power failure, a hydraulic accumulator is built into the system, which allows a number of operations of the jack after the pump has stopped.

Such an actuator, although not a transducer in the accepted sense, is an integral part of a process-control loop. The controller, which receives the signal from the measurement transducer and sends a correcting signal to the actuator, is basically a deviation-detecting amplifier with adjustable gain. The controller also provides for the inclusion of integral-action and

differential-action units, which modify the correcting signal. The time-constants of these units are determined by the plant response.

Future trends

Although analogue measurements are used and accepted for present installations (and have been described here), there is also a requirement for transducers with a digital output. This demand arises from the expanding use of data-logging equipment in process plants and from the design studies at present being conducted to apply digital computers to the control of complete plants.

Summary

A wide variety of transducers are available for measuring all the parameters met in process control. Physical size and weight are of less importance than reliability and flexibility, and the present tendency is to use those units that provide range and zero adjustments, give long-term stability, and are suitable for mounting in any environmental condition.

Regulations for the Electrical Equipment of Ships

THE 4th edition of the Regulations for the Electrical Equipment of Ships has now been published by The Institution and has effect from the 1st September 1961.

The 1st edition of the Regulations was issued in 1919 (forming a companion to The Institution's Regulations for the Electrical Equipment of Buildings, first issued in 1882). The 2nd and 3rd editions of the Regulations for Ships were published in 1926 and 1939, and a supplement to the 3rd edition, dealing mainly with new types of cable and the use of alternating current, was issued in 1947.

Reviewed and recast

For the preparation of the 4th edition, in which the Regulations have been completely reviewed and recast, the Committee on Regulations for the Electrical Equipment of Ships was reconstituted in 1955, and in particular its membership was extended by the addition of further representatives of shipbuilding and shipowning interests. Account has been taken of the great progress in standardization, through the British Standards Institution, that has taken place since the publication of the 3rd edition and supplement, particularly of cables, generators, motors, transformers and radio-interference suppression. This standardization has enabled reference to be made to the relevant standards, with consequent shortening of the Regulations.

At the request of the B.S.I., the Committee on Regulations for the Electrical Equipment of Ships act for the British National Committee of the International Electrotechnical Commission in respect of work falling within the scope of I.E.C. Technical Committee no. 18 'Electrical Installations in Ships', and the work of preparing the 4th edition has proceeded closely in parallel with work for a 2nd edition of the I.E.C. Recommendations for the Electrical Equipment of Ships. The 1st edition of the I.E.C. Recommendations was issued in 1957, and a draft 2nd edition is now in an advanced stage of preparation. So far as national considerations permit, every attempt has been made to ensure that the 4th edition of the Regulations and the 2nd edition of the I.E.C. Recommendations will be substantially in accord.

Copies of the 4th edition may be obtained from the Secretary of The Institution at the following prices: bound in limp cloth 7s. 6d. (post-free), or case-bound in cloth 10s.

The Canberra, a twin-screw turbo-electrically-propelled liner

The Loch Awe scheme

THE North of Scotland Hydro-Electric Board have placed orders for the manufacture and installation of the large pumping and generating plant required for the Cruachan pumped-storage power station of their Loch Awe scheme. The machines will consist of four reversible pump-turbines, with four 100 MW motor-generators.

The equipment is the first of its kind to be manufactured in Britain. Instead of a separate pump coupled to the same shaft as the power-producing turbine, a single-stage combined pump-turbine will be used. This will rotate in one direction when producing power, and in the opposite direction when pumping.

The Cruachan pumped-storage power station, which will be situated underground in the heart of Ben Cruachan, is the major station of the Board's Loch Awe scheme, which also has two conventional hydroelectric stations at Inverawe and Nant.

At night and at week-ends when the demand for electricity is low, the electrical part of the machines will be used to drive the hydraulic part, so that it can pump water from Loch Awe to a reservoir formed by a dam, which will be built across a corrie on Ben Cruachan at the head of the Cruachan Burn. The crest level of the dam will be over 1300 ft above sea-level. During the hours when the demand for electricity is at its peak, water from the reservoir will be fed down sloping shafts to the power station nearly 1200 ft below, and the hydraulic part of the machines will act as turbines driving the electrical part to generate electricity.

MOSCOW IN JUNE

A visit to the Popov Society

The Popov Society was formed to honour the work of A. S. Popov, one of the early radio pioneers; it is composed of several thousand members throughout the length and breadth of the Soviet Union, and it exists to spread information on technical developments in light-current electrical engineering.

In May 1961, the President of the Popov Society, Academician Vladimir I. Siforov, invited The Institution to send two representatives to Moscow to attend the annual meetings of the Society. Mr. J. H. H. Merriman, M.Sc., Member, and Mr. F. Horner, M.Sc., Associate Member, were asked to represent The Institution, and have written this account of their experiences.

THE timing of the meetings of the Popov Society in June 1961 was particularly interesting to the visitors from the West, since during the preceding week the President of the Popov Society, together with a score or more of presidents of other comparable societies in other technologies, had, as the presidium, attended the All-Union Council of Scientific and Technical Societies of the Union of Soviet Socialist Republics.

Plan for scientific research

At these meetings, the new President of the Academy of Sciences of the Union of Soviet Socialist Republics had outlined the main points of a new single State plan for scientific research. One aim of the plan was to gear science and technology for a 'decisive phase of the economic competition with capitalist societies'. As part of the plan for the future, it was foreseen by the President of the Academy that half the scientific establishments of the Academy would be transferred to industry, tying research more closely to production and leaving the Academy free to concentrate on longer-term projects. It was therefore particularly interesting to visit the Soviet Union hot on the heels of an important policy statement and to observe these developments in their native context.

St. Basil's Cathedral, Moscow

The Soviets claim some 350000 scientific workers in nearly 4000 scientific establishments, the programmes for most of these being relatively closely controlled by the Academy of Sciences.

Electronics in everyday service

The meetings of the Popov Society opened on the 19th June in the chandeliered splendour of the hall of Dom Columni, the 'House of Columns', on the corner of Pushkin Street. The hall is part of a group of buildings, Dom Soyuzov, built in 1780, used formerly as a club for Russian nobility and now used for principal trade-union gatherings. The President of the Society was supported on the platform by his officers and non-Soviet delegates, of whom five were from the West and a score or more from communist-bloc countries.

In an opening speech of welcome, Academician Siforov referred to the rapid advances of Soviet radio engineering and spoke of the need to develop further the business of electronics in the everyday service of his country. It seemed clear from his opening remarks, and from much that we saw later, that developments in consumer industries and in the application of electronics to fields as diverse as business administration and agriculture are already in train.

Review of radio engineering

After opening the proceedings, Academician Siforov delivered the first of the formal technical lectures. His lecture was a broad review of the achievements of Soviet radio engineering and a statement of the tasks to be tackled in the immediate future. Much of this had a very familiar ring. He spoke of the growing need to improve reliability in complex systems, of the way in which the search for improved reliability was producing a requirement for components of increased intrinsic reliability, and of 'the need of concentration

Mr. F. Horner and Dr. Y. Lichter outside the Atmospherics Laboratory of the Research Institute of Terrestrial Magnetism, the Ionosphere and Radio-Wave Propagation

of development on miniature capacitors, amplifiers and filters'.

He mentioned, too, the importance of developments in low-noise high-capacity transmission systems, the necessity to study the theoretical bases of data-handling systems, and the particular need for the development of nanosecond techniques for use in nuclear research. In an interesting aside, he suggested that the use of digital computers in planning the national economy had already been worth 10^9 roubles. (This statement worried the foreign delegates and their interpreters, who were obviously anxious to know whether the figure was in terms of the former or the present revalued currency! So far as could be found out, the sterling equivalent was £40 million.)

Academician Siforov suggested that electronics could contribute to such diverse fields as remotely controlled apparatus for use in agriculture (the term 'tele-auto-vidi-control' was coined) and the use of high-stability frequency sources as means of probing into gravitational-field and special relativity problems.

Gravitational waves

The second general survey paper of the opening session (by custom a paper given by an invited speaker working on the frontiers of knowledge in a field allied to radio) was delivered by Prof. D. D. Ivanenko on the general subject of gravitational waves. This was a highly erudite display of quick-fire mathematical virtuosity that very soon had the interpreters mute. Nevertheless, your representatives perceived through the international language of mathematical equations that a broad survey was being made of the meaning of gravitational fields, of their possible mechanism, and, in a very speculative way, of the possibility of using these fields as communication media. No doubt the formal account of the lecture when published in the Society's journal will be of great interest to specialists in this work.

The blackboards, charts and equations were then cleared away and the meaning of 'symposium' leapt into life as the lecture was followed immediately by a 'little concert', with singers, Spanish dancers, harp duettists, puppeteers, xylophonists and near-Western jazz. (No doubt The Institution's Council will note.)

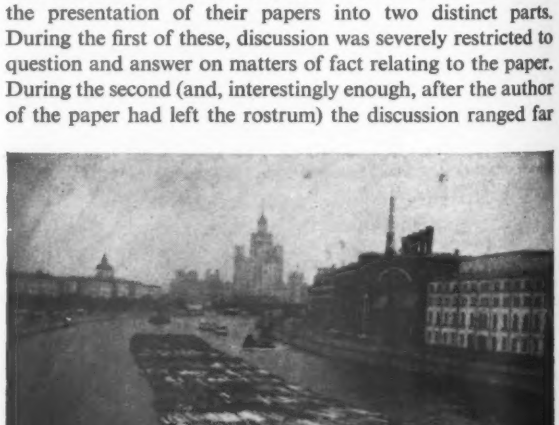
Working groups

The succeeding days of the meetings were occupied by a number of working-group meetings in the House of the Red Army in Kommuny Square. We were invited to attend these groups on one morning and found 14 at work in parallel, each concerning itself with papers on a section of electronics work. The subjects covered were information theory, aerial systems, receiving–transmitting systems, cable (telephone and telegraph) systems, television, general radio theory, broadcasting acoustics and recording, telemagnetics, ferrites, microwave electronics, radio measurements, propagation, semiconductors and cybernetics. With this wealth of information and the obvious difficulty of interpretation, we were able to select only a few papers.

We heard an interesting, but extremely detailed, series of papers on wave propagation. The experimental work discussed was mainly along lines well publicized in world literature. There was, for example, a paper describing measurements on diffraction at very high frequencies over mountain ridges in the region of Lake Baykal. The object of this paper was to explore the possibility of extending by these means the area coverage of, for example, the Irkutsk television-broadcast station. A second paper dealt with work on the measurement of meteoric-trail movements and paid graceful tribute to the pioneer work of Jodrell Bank in this field.

Discussion and criticism

An interesting characteristic of the presentation of these technical papers was the great preoccupation with theoretical bases of the work and the relegation of experimental details to an almost trivial concluding sentence. We found, also, that the custom of the Society was to divide discussion after the presentation of their papers into two distinct parts. During the first of these, discussion was severely restricted to question and answer on matters of fact relating to the paper. During the second (and, interestingly enough, after the author of the paper had left the rostrum) the discussion ranged far



Lumber in transit on the Moskva River

and wide and was critical, often in a highly personal way, to an extent that was unfamiliar to us. Indeed, we were told that at times in certain sessions there was much opportunity for self-criticism and self-examination by the author during these discussion periods.

Russian hospitality

While the 700-odd main body of Soviet delegates attended these detailed sessions for the remainder of the week, traditional Russian hospitality was accorded to the foreign delegates, who were invited to see some of the work going on in universities and State research establishments. The visit to the Moscow University Faculty of Physics followed very closely on the lines of the visit made by Dr. R. C. G. Williams in 1960, but certain aspects of university life not recorded by him seemed of interest to us.

We were told, for example, that of 475 students entering for a degree course in physics, some 450 would be expected to pass. We were told, also, that entry to the university is by highly competitive examination and that before sitting this examination most candidates attend a series of five or six general review lectures in which the syllabuses of the subjects in which they are to be examined are reviewed and likely question topics are discussed in detail.

Our visit to the Moscow television centre was arranged for the one day in the week when an additional channel is radiated in colour. The system used was a modified N.T.S.C. one. We had no opportunity of observing anything other than film pictures and had no chance to see 'off the air' pictures, although we were told that some 1600 receivers were in use in the Moscow area, primarily, we gathered, by officers connected in one way or another with the service as part of system evaluation, or in 'Palaces of Culture'.

Research establishments

Of most interest, technically, were two visits paid to research establishments, the first of which was to the Research Institute of Terrestrial Magnetism, the Ionosphere and Radio-Wave Propagation, and the second of which was to the Institute of Radio Engineering and Electronics of the Academy of Sciences. The former, some 40km south of Moscow, was concerned primarily with ionospheric and other allied propagation work. The latter, occupying buildings formerly used by the Faculty of Physics of the University in the centre of Moscow, was engaged on a wide variety of fundamental electronic development, ranging from mathematical analyses of communication systems to the assessment and examination of plasma devices and semiconductor materials.

In both institutes we were struck by the single-minded purposefulness of the young physicists and engineers, with whom we had the opportunity to discuss technical problems. A large proportion, perhaps half, of the graduate staffs of these institutes were women. To the extent that we were shown, their work was mainly concerned with a recapitulation of work already published in the West, but undoubtedly the capacity exists for original work and much that is novel must be expected from these sources in the future. Wherever we went we were struck, too, by the desire among the young scientists and engineers, first for technical information on comparable activities in the United Kingdom, and secondly to convince us that they were in a position to match our work and our development.

Single-mindedness to the ideology of Soviet society seemed apparent in the procedure whereby, in research organizations or academic establishments, notice boards proclaimed and portrayed photographs of 'The best workers of the month', the selection being made at monthly meetings of all staff of the establishment, from director to doorkeeper. At these meetings, points were awarded to take account of not only the worker's behaviour in the laboratory, his output or the results that he had achieved, but also his behaviour at home, his contribution to the society or neighbourhood unit in which he lived, and his general political consciousness.

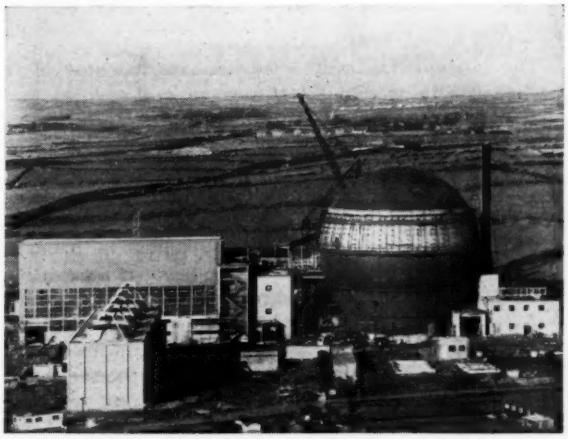
Impressions

These, then, are some of the points that struck two visitors to the Soviet Union. The visit lasted only one week. The facts gathered can be only samples of a mass of information. Conclusions may therefore be tentative and incorrect. But the impressions gathered are lasting, and the memory remains of virile, vigorous and competent youth, undertaking its work in a society which shares with us the use of the nouns freedom, democracy, information, education and competition but which does not share our interpretation and usage of them.

Successful tests at Windscale

SUCCESSFUL tests were carried out recently on the 135ft-diameter containment building that encloses the nearly-completed advanced gas-cooled reactor (A.G.R.) belonging to the United Kingdom Atomic Energy Authority at Windscale, Cumberland. Sub-atmospheric, strength and leak tests gave satisfactory results. The pneumatic strength test was carried out at 12·5lb/in.^{2}

The A.G.R. represents the next phase of development of the graphite-moderated gas-cooled reactor beyond the basic Calder Hall design.



Advanced gas-cooled reactor at Windscale
Four cooling towers can be seen in the foreground

THE ACTION OF THE SINGLE-PHASE INDUCTION MOTOR

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Simplification of the theory of the single-phase induction motor by the concept of counter-rotating magnetic fields may result in incorrect deductions, owing to the concept being wrongly applied. This article compares the correct and incorrect approaches to the problem.

Prof. Williams is Professor of Electrical Engineering, and Dr. Laithwaite is in the Electrical Engineering Laboratories, University of Manchester.

Prof. F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S., MEMBER, and **E. R. LAITHWAITE**, M.SC., PH.D., ASSOCIATE MEMBER

THE theory of the polyphase induction motor has been simplified to the point where it can be appreciated by the 5th-form schoolboy. In a 3-phase motor, the fields produced by three separate coils can be combined vectorially for different instants of time, and a demonstration of the rotating magnetic field results. Such elementary treatment can be misleading for two reasons:

(1) No mention need be made of the space distribution of the magnetic field
(2) No account is taken of the effect of the rotor conductors.

There is no real danger in introducing the 3-phase motor in this way, since the development of the real machine with distributed windings and a sinusoidally space-distributed air-gap flux can follow naturally. It is when the single-phase induction motor is introduced to the student (usually after the polyphase machine) that the original simple concepts tend to be carried over and result in some erroneous ideas about single-phase motors.

Rotating-field concept

The introduction of the single-phase machine often begins something like this: 'A single coil such as that shown in Fig. 1a generates a pulsating field, which may be represented by two equal and oppositely rotating fields as shown in Fig. 1b, since resolving the fields of Fig. 1b horizontally gives zero at all times, while resolving vertically yields $B \sin\omega t$ as in Fig. 1a.'

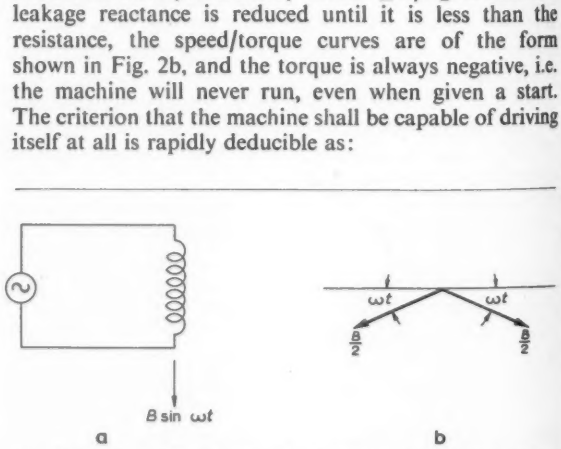
There is, however, a fallacy in this statement. It lies in the fact that the single coil is said to produce a pulsating field. The air-gap field is the resultant of stator currents and rotor currents and is, in general, not a pulsating quantity. It is purely pulsating only if the rotor currents are zero or if they flow exclusively round the same axis as do the stator currents, which will be true only when the rotor is stationary.

The fallacious argument proceeds somewhat as follows: 'Since the counter-rotating fluxes act separately on the rotor, the single-phase machine can be replaced by two identical polyphase machines on the same shaft, connected for opposite rotation. Since equal flux is required in the two machines, they must be electrically connected in parallel' (it being assumed that the stator impedance is zero, as is customary in elementary approaches). Since induction motors are commonly supplied from a constant-voltage source, it is usually assumed that the two parallel-connected machines are supplied at constant voltage, so that the counter-rotating fluxes are not only equal but constant. Connection to a constant-voltage source is, however, a matter of convenience, the important thing being that the machines are connected in parallel. With this equivalent arrangement, a number of properties of single-phase machines can be deduced, many of which are qualitatively correct but quantitatively incorrect. For example, two speed/torque curves can be drawn as shown in Fig. 2a, the net torque being indicated by the shaded area, and the following deductions may be made:

(a) There is no starting torque
(b) The machine will run in either direction once it is given a start
(c) The machine will run light at slightly less than synchronous speed.

Correctness of conclusions

These conclusions happen to be qualitatively correct, but if one pursues this fallacious argument further one may be tempted to ask what fixes the shape of the speed/torque curves of the polyphase motor shown in Fig. 2a. Everyone agrees that this is the ratio of resistance to standstill leakage reactance (R/X_L); in fact, the curves have peaks at slip values $\pm R/X_L$. If then the leakage reactance is reduced until it is less than the resistance, the speed/torque curves are of the form shown in Fig. 2b, and the torque is always negative, i.e. the machine will never run, even when given a start. The criterion that the machine shall be capable of driving itself at all is rapidly deducible as:



1 *Resolution of a pulsating flux into counter-rotating components*

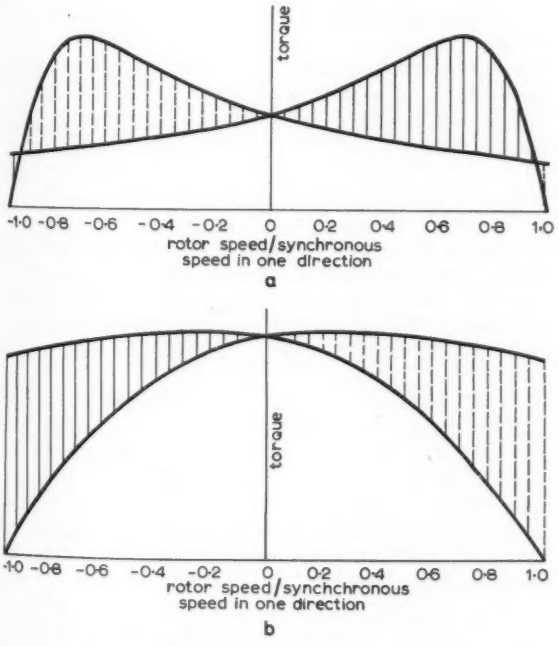
$$\frac{X_L}{R} > 1 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

It is at this point that doubt may begin to grow in the mind of the student. Leakage reactance is caused by leakage flux, and leakage flux is a waste—an imperfection. The student may well ask: 'Can it be true that the single-phase motor runs only if its magnetic circuit is more imperfect than its electric circuit? Is the remedy for a machine which fails to run to make it more imperfect?' The answer to this question is clearly 'No', and the proper procedure is to eliminate the imperfections in the theory.

Correct version of the counter-rotating approach

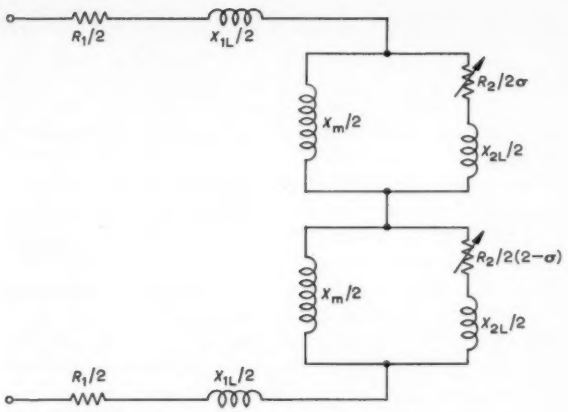
There are two ways of approaching the theory of the single-phase induction motor that yield correct answers: one is the 'cross-field' approach, which is difficult, and the other is the 'counter-rotating current-sheet' approach, which is simple. In a single-phase machine, the stator current is a pulsating quantity at all speeds and cannot be made otherwise by the flow of rotor currents. Thus the pulsating stator current can at all times be represented as the resultant of equal counter-rotating current sheets.

If the stator coil is concentrated as in Fig. 1, there will be pairs of counter-rotating harmonics with 2-, 6-, 10-, 14-poles, etc.; but, if the winding is properly distributed, only the 2-pole counter-rotating pair will remain. Since


torque
-1·0 -0·8 -0·6 -0·4 -0·2 0 0·2 0·4 0·6 0·8 1·0
rotor speed/synchronous speed in one direction
a
torque
-1·0 -0·8 -0·6 -0·4 -0·2 0 0·2 0·4 0·6 0·8 1·0
rotor speed/synchchronous speed in one direction
b

2 *Constant-voltage speed/torque curves*

a $\frac{R}{X_L} < 1$ b $\frac{R}{X_L} > 1$ —— positive torque - - - - negative torque



3 *Equivalent circuit of a single-phase induction motor*

once again these will act independently on the rotor, the single-phase machine can again be replaced by two identical polyphase machines on the same shaft with their phase sequences arranged for opposite rotation. However, since it is essential that the currents in these two machines remain equal at all times, it is *essential* to connect them in series, and it is *convenient* when discussing speed/torque curves to assume that this current is held constant.

The equivalent circuit of the motor is as shown in Fig. 3. As the slip is reduced, the forward-going machine develops a higher impedance, thereby capturing a greater proportion of the applied voltage and a greater flux density. The backward-going flux continues to decrease as the speed increases.

The confusion between X_L and X_m

On the one hand, the incorrect approach, in which the two flux components are assumed to be equal at all speeds, leads to the conclusion that the single-phase motor may be represented by two polyphase motors, coupled mechanically for opposite rotation and connected electrically in parallel.

If the magnetizing impedance of a polyphase motor is considered infinite, the torque equation is simply:

$$T = \frac{k\sigma \frac{R}{X_L}}{\left(\frac{R}{X_L}\right)^2 + \sigma^2} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where σ is the fractional slip and k is a constant. The expression for the net torque of two machines in parallel is then given by:

$$T = \left[\frac{\sigma \frac{R}{X_L}}{\left(\frac{R}{X_L}\right)^2 + \sigma^2} - \frac{(2-\sigma)\frac{R}{X_L}}{\left(\frac{R}{X_L}\right)^2 + (2-\sigma)^2} \right] \quad . \quad (3)$$

Solving eqn. (3) for $T = 0$ gives the running-light speed ω_0 as:

$$\omega_0 = \omega_s\sqrt{\left[1 - \left(\frac{R}{X_L}\right)^2\right]} \quad . \quad . \quad . \quad . \quad (4)$$

Eqn. (4) can be used to deduce condition (1), known to be wrong.

If, on the other hand, the equivalent circuit of Fig. 3 is used to evaluate the torque, assuming the magnetizing reactance to be infinite, the running-light speed is seen to be ω_s, and at that speed the backward-going field is zero. The more interesting result, however, is obtained by ignoring the leakage inductances in Fig. 3 and taking account of the magnetizing reactance X_m. By equating the powers absorbed in the rotors of the two machines, the running-light speed is seen to be:

$$\omega_0 = \omega_s\sqrt{\left[1 - \left(\frac{R}{X_m}\right)^2\right]} \quad . \quad . \quad . \quad . \quad (5)$$

This is the condition for equal but opposite torques, a result obtained, after some labour, by Behrend prior to 1920. This shows that a machine with a perfect magnetic circuit functions perfectly as a single-phase motor, running light at ω_s and developing positive torque for positive speed.

The criterion for the machine to run at all is $X_m/R > 1$, and the remedy for a machine that will not run is to make its magnetic circuit *better*. Such was Tesla's deduction, which enabled him to invent the induction motor. The curiously analagous roles played by X_m and X_L in the two cases perhaps become most apparent in the calculation of the speed/torque equation of a polyphase motor fed at constant voltage [in which one assumes $X_m = \infty$, namely eqn. (2)] and the speed/torque equation of the same motor fed at constant current (assuming $X_L = 0$). The latter yields the equation:

$$T = \frac{k'\sigma\dfrac{R}{X_m}}{\left(\dfrac{R}{X_m}\right)^2 + \sigma^2} \quad . \quad . \quad . \quad . \quad . \quad (6)$$

This is of the same form as eqn. (2), with X_m replacing X_L.

The blame

The blame for spreading the heresy that two machines in parallel correctly represent a single-phase motor has been laid on Ferraris*, though some of his contemporaries were probably equally guilty. The concept of counter-rotating components was brilliant in itself but was applied to the wrong quantity, i.e. to the flux instead of the current.

Laboratory tests on single-phase induction motors should preferably be made on large machines for which $X_m \gg X_L$. Tests on small machines may easily prove misleading, since X_m and X_L may be comparable in value, so that such tests will not differentiate sharply between eqns. (4) and (5).

* VEINOTT, C. G.: 'Theory and design of small induction motors' (McGraw-Hill, 1959)

The majority of so-called single-phase motors found in practice are, strictly speaking, 2-phase machines. They usually carry an auxiliary starting winding or pole-shading system to enable them to develop torque at standstill. It should perhaps, therefore, be emphasized that the foregoing discussion relates only to the true single-phase motor.

Two-phase drag-cup motors

An interesting example of the application of single-phase principles is to be found in 2-phase servomotors in which one set of windings is permanently connected to a source of supply, while the other is connected to a supply whose magnitude or phase is varied according to the control signal. When the latter is zero, it is essential that the motor shall not run, which is to say that the motor shall be sufficiently bad that $X_m/R < 1$. Often the rotor of a small motor of this type consists of a thin copper cylinder surrounding a stationary core. In this way the rotor inertia is reduced to a minimum. The motor is known as a drag-cup motor. It has often been stated that these motors should be *designed* in such a way that they will not run when the control signal is zero.

An expression for X_m/R may be developed in terms of the physical constants of the machine† showing that:

$$\frac{X_m}{R} = \frac{8p^2\mu_0 f}{\rho_r g} \quad . \quad . \quad . \quad . \quad . \quad (7)$$

where p is the pole pitch, f the supply frequency, ρ_r the surface resistivity of the rotor and g the effective air-gap.

For drag-cup-type motors, the smallest value that the product $\rho_r g$ can have occurs where the mechanical clearance is zero. If this ideal could be achieved, then, for a given rotor material, the product would be independent of ρ_r or g separately, for to double the conductor thickness is to halve ρ_r and double g. The ideal value for $\rho_r g$ is therefore equal to the volume resistivity of the best conductor obtainable, assuming the effective end-ring losses to be zero. Any mechanical clearance or end-ring loss only raises the value of $\rho_r g$ above the ideal and reduces X_m/R. The condition necessary for single-phase running is therefore that $8p^2\mu_0 f/\rho_r g$ shall be greater than unity.

Using the ideal value for $\rho_r g$ for copper at normal running temperatures, a 50c/s single-phase machine will run only if p is greater than 2·3cm. This means that 2-pole drag-cup motors of diameter less than 1·47cm, 4-pole motors of diameter less than 2·94cm, etc. cannot be designed to run on single phase. The corresponding figure for aluminium is 1·74cm diameter for a 2-pole machine of similar type.

† WILLIAMS, F. C., LAITHWAITE, E. R., and PIGGOTT, L. S.: 'Brushless variable-speed induction motors', *Proceedings I.E.E.*, Paper 2097 U, June 1956 (104 A, p. 102)

Continued at foot of p. 553

THE NEW DIVISIONAL STRUCTURE OF THE INSTITUTION

More details are now available about the new Divisional structure under which it is planned to replace the existing four specialized Sections by a series of Technical Groups contained in three broadly based Divisions (see pp. 404 and 433 of the July 1961 *Journal*).

The first list of Technical Groups, the final composition of which is still under discussion, is likely to consist of approximately 30 Groups in all, i.e. 10 in each Division. Following approval of the necessary Bye-law changes and as soon as possible during the course of next session, each member of The Institution (except Students) will be sent a form on which he will be asked to register, if he so wishes, for the Division or Divisions in which he can demonstrate a professional interest, and to indicate, in particular, the individual Technical Groups with which he wishes to be specially associated.

This registration will replace the present membership of the specialized Sections and will entitle members so registered to take part in the elections to the appropriate Divisional Boards and to receive information about Divisional and Technical Group activities.

Wider opportunities

The Technical Groups will be, to use a military expression, the front-line units, responsible for both reconnaissance and action in their respective sectors of the front. For this reason, each Technical Group will be guided by a committee that should be a compact group of experts in the specialization concerned, gathered round a nucleus of a chairman and possibly one or two other members, drawn from the responsible Divisional Board.

Thus the opportunities for service on Institution committees will be wider than they have been in the past; it is particularly hoped that those actively engaged in the practical advancement of all aspects of electrical engineering will be able to give The Institution the benefit of their up-to-date knowledge and experience. Furthermore, as a result of the greater subdivision of specializations, the membership as a whole will be encouraged to participate more fully in Divisional and Technical Group activities, since each member will be able to identify himself more closely with the smaller areas of interest in which Technical Groups will operate.

The scopes of the 'Power' and 'Electronics' Divisions are implicit in these titles, subject to the proviso that applications of electronics in power systems, for instance, will fall within the scope of the 'Power' Division, although the particular technique may have originated in the area of the 'Electronics' Division; this principle applies throughout the scheme.

The central Division, which during the evolution of the plan has been known as the 'General' Division, will cover fundamental development in electrical science and other subjects of common interest, and it is now thought that its character could be more accurately represented by the title 'Electrical Science and General'. Technical Groups within its area will deal with such subjects as fundamental electrical theory and measurement, education and training, and fundamental research in, and the development of, materials and new techniques. In the latter respect it will act as a source from which developing specializations may be transplanted in due course to one or other of the two more specialized Divisions.

Constitutional details

Much progress has been made in working out the constitutional details of the new structure, and particular attention has been paid to the composition of the Divisional Boards and the way in which they will be represented on the Council and standing committees. As the proposals stand at present, each Board will be represented on the Council by a strong contingent consisting of three office-bearers of the Division, including the chairman, and two serving ordinary members of the Board. Each of the standing committees of the Council will contain at least one official representative of each Division; and representation on the main Papers Committee, which will devote increasingly greater attention to the co-ordination of The Institution's learned-society activities, will be specially strong.

The flexibility of the new structure will enable the local Centres to operate specialized units within their areas in the manner best suited to local conditions, and Headquarters will be able to provide administrative servicing for whatever combination of Technical Groups or Divisions a local Centre Committee decides to adopt. A further advantage lies in the fact that it will now be easier to achieve immediate and practical co-operation with the many specialist societies in the electrical engineering field, since the Technical Groups will often reflect their particular interests directly.

Special General Meeting

The extent of the Bye-law changes necessary for the new Divisional structure to be introduced has now been ascertained, and a schedule of amendments will shortly be submitted by the Council to a Special General Meeting of Corporate members. It is hoped that this meeting can take place early in the new session, and Thursday, 2nd November 1961, has been provisionally earmarked for this purpose; it is important that there should be as little delay as possible in seeking the approval by the Privy Council that is necessary before changes to the Bye-laws become effective. If this date is adhered to, the Special General Meeting will start at 5 p.m. and will be followed at 6 p.m. by an Ordinary Meeting at which Mr. T. Somerville, B.SC., MEMBER, will deliver a lecture on 'Acoustics and the electrical engineer'.

Continued from p. 552

By way of contrast, it is interesting to note that polyphase machines can be made to operate in sizes as small as it is possible to construct them mechanically. It is also interesting to note that, historically, the single-phase machine preceded the polyphase machine, and its action at that time was properly understood. It was only after the advent of the polyphase machine that the rotating-field theory gained ground and was most unfortunately misapplied to the single-phase motor.

Summary

It has been shown that many of the well known properties of the single-phase motor may be predicted by the incorrect approach, provided that the results are only qualitative. A quantitative analysis, however, reveals the fallacy.

An automatic machine for building cycle wheels 621–526

Automatic assembly has been in use in the electronics industry for the last ten years, and is also employed effectively in making electrical accessories for motor cars and similar components. But in most industries the development of automatic assembly has been slow, even where assembly contributes a substantial part of the manufacturing cost. Compared with other industrial processes, assembly operations are difficult to mechanize. An exceptionally close degree of integration is needed between the electrical and the mechanical engineering at all stages of design, and in some cases the major difficulty lies in devising a method of control for a system too large or complex for formal analysis. These points are illustrated in this article, which describes an automatic machine used in building bicycle wheels.

The article is based on part of the authors' lecture to the Measurement and Control Section at Savoy Place on the 7th March 1961 entitled 'The automatic control of machines for assembling mechanical components'.

The authors are at Tube Investments Technological Centre.

A. V. HEMINGWAY, B.SC.(ENG.), MEMBER,
and **R. L. DRESSLER**, B.SC.(ENG.), ASSOCIATE MEMBER

A CYCLE wheel is built by an operator threading some 40 spokes through the hub and rim (lacing) and tightening the spokes by nuts (nipples) screwed on the spokes at the rim end.

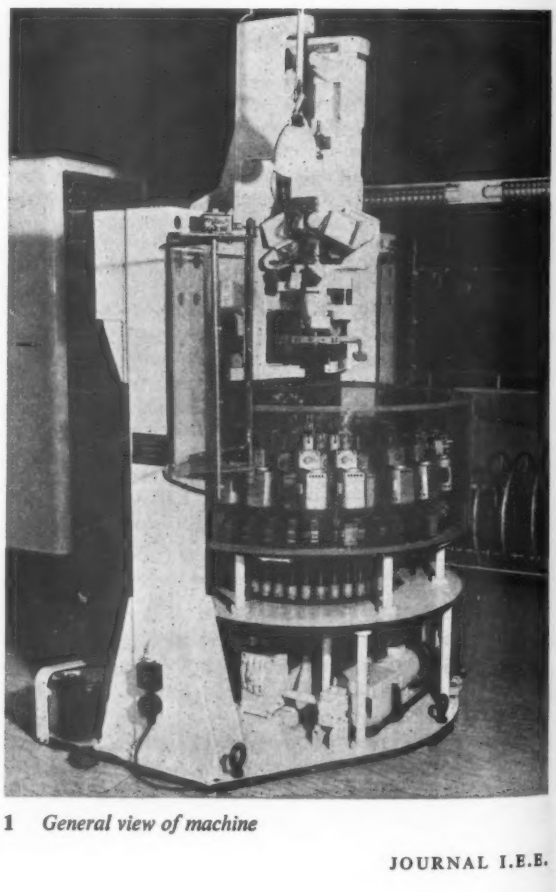
When using hand methods, the wheel is finally mounted on its spindle and the operator repeatedly tightens or loosens individual spokes until the wheel runs true. He must maintain approximately equal tensions in individual spokes to avoid breakage in service, and the general level of spoke tension must be high enough to keep the wheel rigid under the rider's weight and thrust. This hand 'trueing' is a highly skilled, and therefore costly, operation, and the work is slow and monotonous. Design was therefore started of a machine that would accept a loosely laced wheel and would tension and true it in a single operation.

In one type of machine, currently available, the hub and rim are clamped concentrically, and equal torque is applied to each spoke nipple. This tightens the wheel rapidly and would result in a true-running wheel if the components were perfect. But, in practice, economic tolerances are necessary on all components, and the distortions they produce can be corrected only by making adjustments to individual spokes. A successful trueing machine must incorporate some method of making and controlling these adjustments.

In other words, the spokes must be tensioned with reference to the shape of the wheel being produced, and, to eliminate errors due to bearings, the rotational axis of the spindle is the only true reference against which the wheel can be judged. The wheel must therefore be built in conditions similar to those in a bicycle, that is, with rotation between wheel and spindle; the 'wobble' in the wheel is then measured, and, by 'feeding back' a signal representing the wobble, the building can be controlled. This is a similar (but much faster) action to that employed by the hand truer.

General description

Fig. 1 shows a general view of the machine. The operator places the loosely assembled wheel horizontally into the machine. All subsequent actions are automatic. From a grip on the hub, the wheel is pulled downward so that each spoke drops through a slot in a motor-driven box spanner. The spanners then move radially outward to engage the nipples, and at the same time an arm carrying two magnetic sensing heads is lowered and clamped onto the wheel spindle. The arm is motor-driven at 250r.p.m. throughout the tensioning, so that, rotating on the wheel's own bearings, the sensing heads



1 *General view of machine*

pass close to the rim and produce error signals if the wheel is not flat and concentric.

The signals are fed back to control the spoke motors, which are switched on and off in suitable groups to tension the wheel while keeping the errors to a minimum. Each motor unit incorporates in its drive-shaft a switch designed to close at a predetermined torque that represents the required spoke tension. Closure of all switches indicates that the whole wheel is tight, and all spoke motors are then stopped. The spanners disengage from the nipples, the sensing head lifts, and the finished wheel is released ready for removal by the operator.

Control system

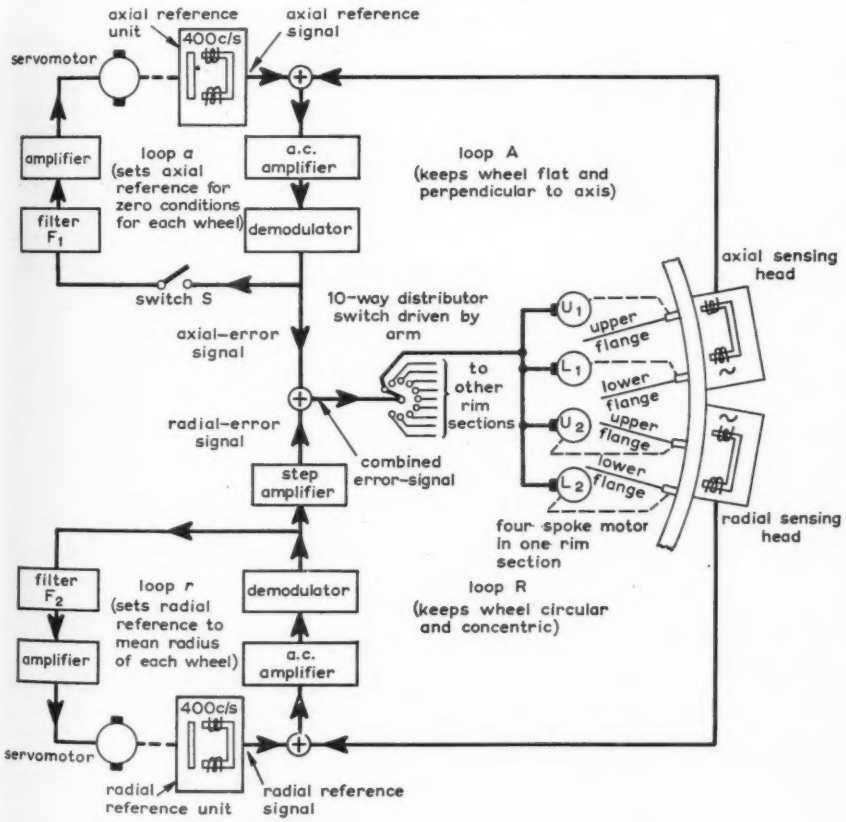
Viewed as a control problem, the system consists of 40 position servos, all mutually dependent, shaping a redundant structure in two planes according to two conflicting criteria (wheel shape and spoke tension). Constants (such as wheel stiffness) vary during the process, and zero conditions (governed by rim dimensions) vary from wheel to wheel. This is a complicated system that is not amenable to formal analysis, but it can be approached better by simplifying it into very broad outlines.

The wheel is considered as ten independent sections, each containing two spokes anchored in the upper hub flange and two in the lower. Fig. 2 shows one rim section with the sensing heads passing it, and also indicates the four main control loops.

In loop A, the sensing head faces the rim downwards and produces an output voltage dependent on its distance from the rim. The output is compared with the reference voltage from loop a (described later) to form the axial-error signal. This signal splits into two channels (not shown) to switch the motors in pairs. If the rim section is low, the upper motors U_1 and U_2 are run to lift it; a high rim is pulled down by running only the lower motors L_1 and L_2. When the rim height is within the given tolerance, all four motors run. This action, which maintains the wheel flat and perpendicular to its axis, is subject to control from loop R.

In loop R, the sensing head faces the wheel radially, so that its output depends on the rim radius. If this is less than the reference level (from loop *r*), the step amplifier produces a large negative output that swamps the signals in loop A, stopping all four motors. Continued tightening on the other side of the wheel will bring the rim radius back within limits, so that only forward rotation of the motors (tightening) is necessary, provided that large overcorrection of error is avoided.

The drive to the arm incorporates a 10-way switch, which transfers the combined error signal to the appropriate group of motors as the sensing heads pass from one rim section to the next. For each rim section, the average error signal is stored on capacitors while the arm is scanning the other nine, so that the motors continue running until reset at the next passage of the arm.



2 *Block diagram of control system*

Adjustment for rim diameter

Since individual rims vary slightly in width and diameter, the reference voltages must be reset for each wheel before tensioning begins, and are therefore obtained from units similar to the sensing heads but with armatures that can be adjusted by servomotors. To make this adjustment, switch S in loop a is closed and the axial-error signal is fed to the servomotor. But filter F_1 has a time-constant several times greater than the time of arm rotation, so

that it passes only the average error. The servomotor adjusts the reference core to take account of this average, thereby giving the correct setting, which is retained by opening switch S. This initial zero setting compensates for slight variations in the position and angle at which the arm clamps on the spindle, and without it wheels could be built axially displaced along the spindle.

Loop r functions in a similar way to set the radial reference to the average radius of the wheel before tensioning. This is necessary because the spokes are not able to contract all wheels to a standard radius. However, a slight contraction occurs as the spokes tighten, and the loop is left in circuit during tensioning to correct the average accordingly.

During lacing, nipples will have been screwed on to their threads by varying amounts, and may also run at different speeds during tensioning. It is therefore possible to build a tight true wheel with some spokes completely loose, which is not acceptable. Loose spokes are prevented by dividing the tensioning into three stages.

In the first stage, screwing torque is limited by operating the motors with reduced field current; the motors run fast but stall at a low spoke tension, leaving the wheel only roughly true. In the second stage, the control is interrupted, so that all motors attempt to run, thus bringing any loose spokes up to the stalling tension. Control is restored for the third phase, and full field is applied to enable the wheel to reach full tension. This is indicated by closure of all the torque switches, and the wheel is complete.

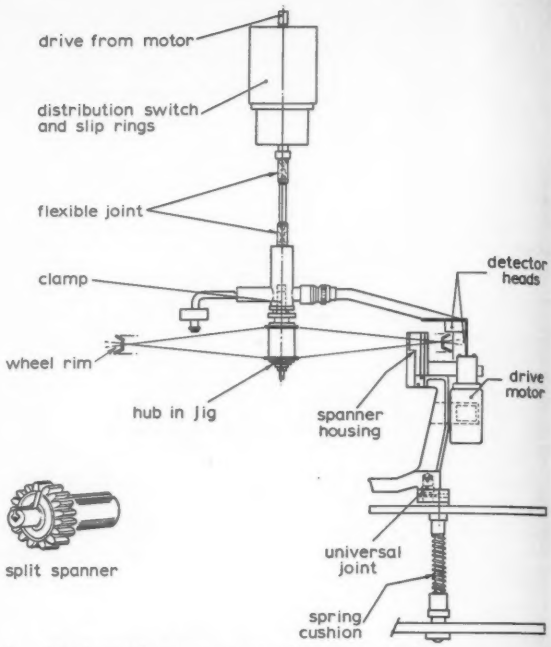
Design features

The control system described above can produce a true wheel only if the rim is free, during tightening, to take up the position demanded by spoke tensions. This condition requires that the spanners should apply pure torque to the nipples, without exerting other deflecting forces. To approach this ideal, each spanner with its associated drive motor is built as a separate unit (Fig. 3), which is spring supported and pivots on a universal joint to give the necessary freedom, leaving the rim 'floating'.

A second condition for success is that the measuring arm shall rotate about the true axis of rotation of the wheel. This means that the drive must be transmitted through universal joints to avoid external restraint and that the rotating mass must be dynamically balanced to avoid deflection of the arm by centrifugal forces.

After tensioning, the spanners slide off the nipples along the spokes, and their driving motors run as simple on–off servos to bring the slots vertical. This action, which is necessary before the spokes can pass up through the slots in the housings, is controlled by a simple selector switch on each spanner shaft. The rotating arm also moves to a safe position before removal of the wheel. The mechanical actions in loading and unloading are controlled by a camshaft driven through an electric clutch.

Electrical gear is largely made up of standard components, and electronic circuits are of simple well known



3 *Mechanical arrangement of detectors, wheel support and screwing spanners*

form. The sensing heads consist of double-wound laminated U-shaped cores facing the rim, which forms part of the iron circuit. Their primaries are excited at 400c/s from an oscillator, and the secondaries produce an output depending on the air-gap, which varies about a mean of $\frac{1}{8}$in. For simplicity, the spoke-motor armatures are switched by relays arranged to give dynamic braking, the relay coils being connected in valve anode circuits to facilitate control from the stored error signals.

Machine performance

The stability and accuracy of the system depend on the amplifier gains, pick-up sensitivity, motor gear ratios and dead zone allowed before switching the motors on or off. A compromise has been obtained experimentally that enables the machine to produce wheels accurate within $\pm 0{\cdot}015$in. A machine has been installed on a standard bicycle-production line where it is used by an unskilled female operator to produce about 60 wheels per hour.

Summary

To reduce hand-assembly costs of cycle wheels, a machine has been built that automatically adjusts a partly assembled wheel to give true running. A rotating arm measures the wheel accuracy, and servo loops control electrically driven box-spanners tightening the wheel. The production machine tensions and trues a wheel in about 60sec, with rim errors of less than 0·015in.

SOUND AND TELEVISION BROADCASTING

European Broadcasting Conference, Stockholm, 26th May–23rd June 1961

At the European Broadcasting Conference, Stockholm, 1952, assignments for v.h.f. (Bands I, 41–68 Mc/s; II, 87·5–100 Mc/s; III, 174–216 Mc/s) sound-broadcasting and television stations in the countries of the European Broadcasting Area were planned. In view of the early stage of development of these services, however, it was recommended that the plans should be reviewed in about five years. In the event it was not possible to consider such a review in 1957, and a second conference was not convened until 1961, when the Administrations of the countries of the European Broadcasting Area accepted an invitation from the Swedish Administration to attend a conference in Stockholm.

Capt. C. F. Booth, C.B.E., Member, who is Deputy Engineer-in-Chief of the British Post Office and led the United Kingdom delegation to the conference, reports the main decisions of the meeting in this article.

In the nine years between the two European Broadcasting Conferences, many new v.h.f. stations were brought into use, some changes were made at the Administrative Radio Conference, Geneva, 1959,* to the frequency allocations to broadcasting in the v.h.f. and u.h.f. bands, and the preparation of assignment plans for Bands IV (470–582 Mc/s) and V (606–960 Mc/s) had become a matter of some urgency. It was apparent, therefore, that the second Stockholm conference would face a heavy task and that a successful conclusion to the work was necessary if the further development in Europe of v.h.f. sound and television broadcasting was to be firmly based.

A particular problem for the United Kingdom was to obtain sufficient flexibility in its assignments to cater for the development and expansion of its services in accordance with future decisions on the line standards to be used and on the number of programmes to be provided.

Terms of reference

The meeting was held in Stockholm from the 26th May to 23rd June 1961. It was attended by upwards of 200 delegates and advisers from 38 Administrations, and by representatives of the European Broadcasting Union (E.B.U.), International Broadcasting and Television Organization (I.B.T.O.), International Radio-Maritime Committee (C.I.R.M.), Inter-Union Committee for the Allocation of Frequencies for Radio Astronomy and Space Research (I.U.C.A.F.), International Frequency Registration Board (I.F.R.B.), and Comité Consultatif International Radio (C.C.I.R.). The United Kingdom delegation included representatives of the Post Office, the British Broadcasting Corporation, the Independent Television Authority, the Ministry of Aviation and the Ministry of Defence.

It is some measure of the increased interest in broadcasting planning that 38 Administrations attended the 1961 conference, compared with 31 at the 1952 conference.

The terms of reference of the conference were to review the assignment plans for sound broadcasting and television in Bands I, II and III, and to prepare assignment plans for Bands IV and V, together with a Regional Agreement for the European Broadcasting Area which would replace the 1952 Agreement.

The technical standards on which the new assignment plans would be based were agreed at a preparatory meeting of experts held at Cannes in March 1961. The comprehensive document† embodying these standards includes propagation curves for the five bands, protection ratios, minimum field strengths to be protected, and details of European television standards. It is worthy of study by those concerned with the planning of broadcasting services in the v.h.f. and u.h.f. bands.

* Booth, C. F.: 'New radio regulations', *Journal I.E.E.*, July 1960, 6, p. 431

† Report of the C.C.I.R. meeting of experts to prepare for the European V.H.F./U.H.F. Broadcasting Conference, Cannes, 1961, published by the International Telecommunication Union, Geneva

V.H.F. assignment plans

At Stockholm it soon became apparent that the very large additional requirements for Bands I, II and III, mainly for medium- and low-power stations, were such that it would not be possible to complete their examination within the period of one month allotted for the conference. Since this could not be extended, it was agreed that only stations of 1 kW (e.r.p.) and above would be included in the plans. Stations of lower power would be dealt with subsequently by a procedure, outlined in the Agreement, whereby the I.F.R.B. would circulate a list of all assignments requested by noon on the 22nd June 1961 to all Administrations of the European Broadcasting Area. In the absence of adverse comment, these assignments would be published and would be given the same status as assignments in the plans.

The two v.h.f. television bands were planned in respect of United Kingdom stations on the basis of the existing standards, 405 lines, 5 Mc/s channel, etc.

Band I—The position of the television assignments in the original Stockholm plan was consolidated, additional assignments for medium-power stations were introduced and, in general, Administrations took action to improve coverage of their services.

Band II—Present United Kingdom use of this band for sound broadcasting is, apart from a few assignments above 95 Mc/s, confined to the range of 88–95 Mc/s to give three programmes of near-national coverage. An increase in the radiated power of existing stations may prove possible, and plans were submitted for possible United Kingdom services in the range 88–100 Mc/s to extend the coverage of the present three programmes and to allow for the development of additional v.h.f. sound-broadcasting services in the United Kingdom if, and when, mobile services are able to vacate all, or part, of the band 95–100 Mc/s. Inclusion of assignments

Delegates of France and the United Kingdom working on the channel-assignment plans for Bands IV and V

in the plan in this way does not carry with it any firm commitment to provide the broadcasting stations concerned.

Band III—The assignments necessary to give near-national coverage of two television programmes in the United Kingdom were incorporated in the plan. The arrangements here will allow for the alternative possibility that the remaining channels in Band III might be wanted to improve the coverage of the existing two services.

U.H.F. assignment plans

Bands IV and V—As for the v.h.f. range, it was necessary to restrict the number of u.h.f. stations for inclusion in the plan to enable the basic planning to be completed during the conference. For this purpose, it was agreed to include only stations of 10 kW (e.r.p.) or more. Stations of lower power would be dealt with using the procedure already outlined for the v.h.f. range.

All the u.h.f. assignments were planned on the basis of 8 Mc/s channels using 625 line standards. It was, of course, made clear that the United Kingdom had not decided on the line standards it would use in Bands IV and V, and to cover the point an additional protocol was made to the Agreement:

'The assignments for television stations in Bands IV and V in the United Kingdom assume the use of 625 line standards with certain parameters. Nevertheless, the Administration of the United Kingdom reserves the right to use such other parameters or standards as may be decided. In this event, the United Kingdom Administration will afford to the broadcasting services of signatory countries, operated in accordance with the Agreement and associated plans, degrees of protection not less than those obtaining under the plans, or those stated in technical standards annexed to the Agreement, whichever are the lower.'

Some of the main parameters of the 625 line systems that it is proposed to use in Europe are summarized in Table 1, and fuller details are given in the report of the C.C.I.R. meeting of experts referred to above.

It was agreed that the 61 8 Mc/s channels in the range 470–960 Mc/s should be numbered consecutively, starting with 21 for the lowest channel (470–478 Mc/s) and proceeding to 81 for the highest channel (950–958 Mc/s).

United Kingdom assignments for medium- and high-power stations to provide four programmes with substantial national coverage, using the whole of Bands IV (470–582 Mc/s) and V (606–960 Mc/s) up to 854 Mc/s, were incorporated in the plan. In planning for the possible use of channels between

Table 1. Parameters proposed by European countries for 625 line television in Bands IV–V using an 8 Mc/s channel

countries	video band	vestigial sideband	separation vision/sound	vision modulation	sound modulation	vision/sound power ratio
	Mc/s	Mc/s	Mc/s			
Soviet Union and Eastern Europe	6	0·75†	6·5	negative	frequency modulation	5 : 1
United Kingdom* and Irish Republic	5·5	1·25	6	negative	frequency modulation	5 : 1
France and Monaco	6	1·25	6·5	positive	amplitude modulation	8 : 1
West European countries (other than above)	5	0·75†	5·5	negative	frequency modulation	5 : 1

* Preferred parameters for a 625line system
† Some countries are considering a vestigial sideband of 1·25 Mc/s

790 and 854 Mc/s, it was appreciated that a final decision on the use of this range by fixed and/or broadcasting services in the United Kingdom had not been taken. In the United Kingdom, the 24 Mc/s gap (582–606 Mc/s) between Bands IV and V is used for the aeronautical radio navigation service.

Radio astronomy

At the conference a plea was made on behalf of the radio-astronomy service that channel 38, 606–614 Mc/s, should be reserved for that service even though it is internationally allocated to the broadcasting service. The Administrations present were sympathetic to the request, and for that reason no assignments in that channel for medium- or high-power television stations in Western Europe have been made in the plan. However, it was indicated by some Administrations that they would wish to operate low-power stations in this channel.

To enable its plans to be integrated with those of nearby Continental countries, the United Kingdom had to abandon its preferred channel grouping, in which alternate channels (8Mc/s gaps between channels), e.g. 21, 23, 25 and 27, would be used for the transmitters serving the same area, and had to adopt a grouping giving the following pattern: 21, 24, 27 and 31.

The planning of the two bands presented many major problems—in particular, agreement on the 'basic lattice' of assignments most suited for Western Europe—and it is of interest to note that a computer was used to assist the work.

Agreement

The assignment plans for the five bands are annexed to the Agreement, which was signed by all 35 Administrations accredited to do so. There were a few minor reservations on the plans, but none was serious as far as the United Kingdom was concerned. The Agreement* will be brought into force on the 1st September 1962, from which date it will replace and abrogate the European Broadcasting Agreement, Stockholm, 1952, and the plans annexed thereto.

In retrospect, it is considered that the conference was very successful in laying down a pattern of development for v.h.f. and u.h.f. sound broadcasting and television in the European Broadcasting Area that will stand the test of time.

* The Agreement and plans will be published, under the title 'The final Acts of the European v.h.f./u.h.f. Broadcasting Conference, Stockholm 1961', by the International Telecommunication Union, Geneva, and should be available in printed form in October 1961

LETTERS TO THE EDITOR

HIGH-VOLTAGE D.C. POWER TRANSMISSION

Dear Sir—Mr. S. A. Vincze in his letter in the July 1961 *Journal*, p. 430, appears to have overlooked the work done by the late J. S. Highfield in Britain.

Highfield was responsible for putting into operation in 1911 a system, similar to the Thury constant-current series one, in the western area of the Metropolitan Electric Supply Co., which was, I believe, operating for many years after the First World War. The generator gave a constant 100 A at up to 5 kV. I remember visiting this novel installation while a student at Finsbury in 1911.

Highfield dealt with the matter fully in three papers read before The Institution, the first (*Journal I.E.E.*, 1907, **38**, p. 471) dealing with the Thury system in general and the later two (*ibid.*, 1912, **49**, p. 848; 1913, **51**, p. 640) including an account of his own work in this field.—Yours faithfully,

J. F. PERRIN
6 Cavendish Avenue
Welling, Kent

18th July 1961

EUROPEAN COMMON MARKET

Dear Sir—Many electrical problems could surely arise with the news of Britain's proposal for entry into the Common Market.

High-voltage d.c. power transmission.....J. F. Perrin, ASSOCIATE MEMBER

European Common Market.....R. K. Streeter, GRADUATE

A construction for dividing tape on reels.....E. Janmoulle, B.SC., GRADUATE; P. D. Hanstead, ASSOCIATE MEMBER

Would British manufacturers produce equipment to the metric system? If we do not produce to the metric system, could we fully open the market to British equipment?

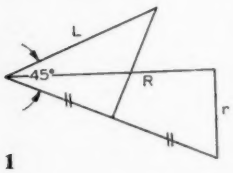
In Europe, the German V.D.E. standard is accepted without question. How would a British manufacturer compete with, for example, explosion-proof equipment to V.D.E. standards, which generally costs two to three times less than the equivalent Buxton Certified Unit. Industrial concerns in the petrochemicals and oil-refining fields might then raise the question of different standards being used, which might lead to the use of the V.D.E. standards or equivalents in Britain, or to the formation of new standards acceptable by all member countries.—Yours faithfully,

R. K. STREETER
2 Meadow Lane
Fetcham
Leatherhead, Surrey

11th August 1961

A CONSTRUCTION FOR DIVIDING TAPE ON REELS

Dear Sir—The construction shown by Mr. F. N. Scaife in the July 1961 *Journal* is one well known to clock-makers, who use it to determine how much of the available space between the main spring arbor and the main spring drum should be occupied by the spring in order to obtain maximum effect from the latter. This can be shown to occur when the spring occupies half the available space.



1

It is interesting that this old problem should have come up again in connection with modern devices.

There is another construction, shown in Fig. 1, which results from the relation:

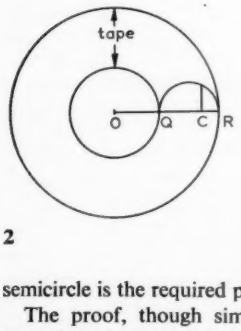
$$L^2 = \frac{R^2 - r^2}{2} + r^2 = \frac{R^2 + r^2}{2}$$

but it has the disadvantage that the construction lines are carried beyond the physical limits of the reel.—Yours faithfully,

E. JANMOULLE
2 rue Ernotte
Watermael
Brussels, Belgium

5th August 1961

Dear Sir—Mr. F. N. Scaife's ingenious construction described in the July 1961 *Journal*, p. 432, can be extended to provide *any* fractional division of tape on a reel (Fig. 2).



2

Draw a radius OR and, as before, erect the semicircle on the part QR containing the tape. Mark point C so that it divides QR in the fraction required; e.g. if it is required to divide at a third of the playing time make CR one-third of QR. Then where the perpendicular at C meets the semicircle is the required point of division.

The proof, though simple, is somewhat lengthy, and I leave it to interested readers to confirm the construction.—Yours faithfully,

P. D. HANSTEAD
Research and Development Department
Central Electricity Generating Board
Portishead, Nr. Bristol

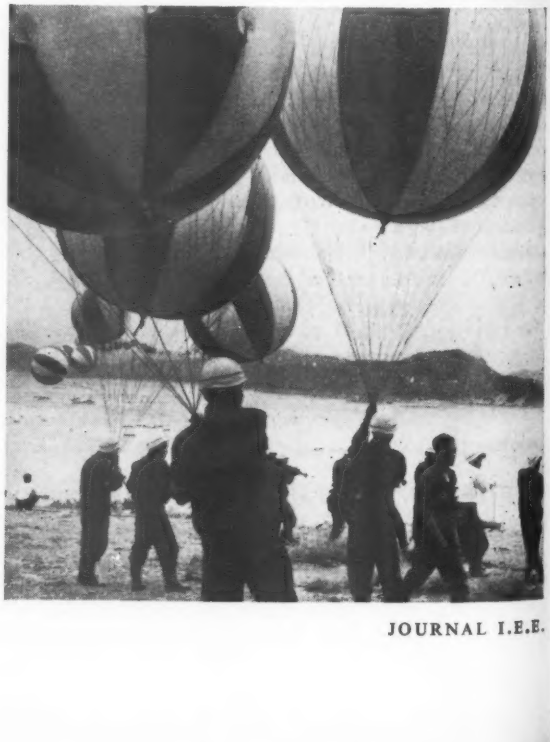
15th August 1961

BRADWELL AND BERKELEY CRITICAL

CRITICALITY was achieved in a reactor at each of the first two commercial nuclear power stations of the Central Electricity Generating Board, at Bradwell, Essex, and Berkeley, Gloucestershire, on the 19th and 27th August 1961 respectively. It is hoped that both will be supplying power to the Grid before January 1962. Both stations will have two gas-cooled, graphite-moderated, natural-uranium reactors. Berkeley's final electrical output will be 275 MW and Bradwell's 300 MW. There will be eight boilers and four turbogenerators per reactor at Berkeley (see illustration) and six boilers and six turbogenerators per reactor at Bradwell.

BALLOON CROSSING

A 9mm pilot wire was carried across the 1860yd-wide sea channel of Naruto, Japan, by 77 hydrogen-filled balloons recently. The pilot wire was to carry electric transmission lines to connect a 375ft tower on Awaji Island to a 480ft one at Naruto, Shikoku. The sea currents are too complicated and swift, and the ship traffic is too heavy, to allow the wire to be put across normally. A five-ton tug towed the balloon-lifted wire across the channel (see illustration below). It is expected that, by the end of this month, 60 MW of power will flow along 35·2mm lines over the link.



The article in this regular monthly feature is based on a current paper read at an Institution meeting. It is written by the author of the paper, who has been asked to make the article, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics discussed. While the article brings out the main points and conclusions of the paper, its content is not necessarily confined to the subject-matter of the original paper

Photoelectric beam-index colour-television system

A brief article based on an Electronics and Communications Section paper (3468) 'Progress report on the development of a photoelectric beam-index colour-television tube and system' by R. Graham, M.Eng., J. W. H. Justice, and J. K. Oxenham, M.A. The paper was published individually in February 1961 and is republished in Part B of the Proceedings this month. It was read before the Section on the 1st May 1961 at Savoy Place. The authors are with Sylvania-Thorn Colour Television Laboratories Ltd.

One of the major problems in launching a colour-television service is the provision of satisfactory colour receivers. These receivers must be capable of giving a good-quality picture of adequate brightness, be reliable and easy to adjust, sell at a reasonable price, and be able to produce a good-quality black and white picture. This last item might easily be a deciding factor in the early days of a colour service.

In the development of such a receiver, the basic requirement is a satisfactory display device. Present-day cathode-ray tubes for colour television fall broadly into two classes, namely multi-gun tubes, which are typified by the shadow-mask and three-gun focus-mask tubes, and single-gun tubes such as the single-gun focus-mask or beam-switching tubes and the beam-index tubes.

Multi- and single-gun tubes

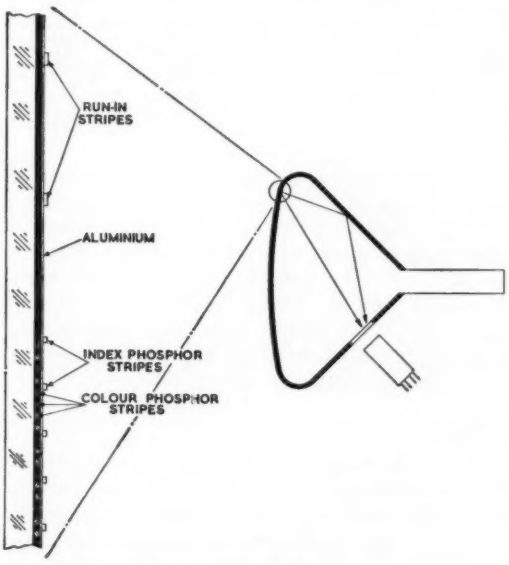
The use of multi-gun tubes, usually with three electron guns, gives rise to two major problems: the transfer characteristics of the guns have to be accurately matched over the whole brightness range, and the separate colour images have to be superimposed over the entire picture area. These features necessitate a multitude of preset adjustments to compensate for deflection aberrations, differences in phosphor efficiency etc., and, of course, manufacturing variations. Maintenance of picture quality has proved troublesome, and it is inherently difficult to reproduce a good monochrome picture.

The single-gun solution of the focus-mask tube avoids these problems but introduces others of its own, such as secondary emission from the grid wires, radiation at the switching frequency, etc. Both the focus-mask and the shadow-mask concepts produce tubes with large and expensive mechanical structures inside the glass envelope, which have to be accurately aligned electron-optically with the phosphor pattern of the screen.

Beam-index tube

The beam-index tube has no internal structure, and is very similar, except for the screen, to a normal monochrome tube. The screen consists of three interleaved sets of equally spaced vertical phosphor lines, one set being of a red fluorescing phosphor, one blue and one green. The normal television horizontal scan performs the colour switching, the electron beam exciting the three colours sequentially. The electron gun must produce a spot that is small enough in the horizontal direction to resolve a single-colour phosphor line.

This type of display can easily produce a black and white picture. If a monochrome signal is applied to the gun, the three phosphors will be equally excited and, since the phosphor pattern is finer than the eye can resolve, a black and white picture will result. The tube has the disadvantage that the



1 *Horizontal sectional view of tube*

Position of the photomultiplier behind the cone of the tube and a section of the face of the tube, with index- and colour-phosphor stripes, are shown

Paper read (continued)

'whiteness' must be built into the screen when the tube is made, requiring that the phosphors be deposited with great accuracy and consistency.

Colour picture

To produce a colour picture, it is necessary to know at any instant of time the position of the beam in the red–blue–green colour sequence. The suggested method is to include in the screen a further set of 'index' lines of an ultraviolet-light-emitting phosphor of short persistence, and to view these with a photomultiplier sensitive only to ultraviolet light (Fig. 1). These phosphor lines are placed parallel to the colour-phosphor lines and in some fixed relation to the colour-phosphor triplets. An index signal is generated by scanning these index lines and is used to produce a sequential colour signal to modulate the tube.

The beam-index system has many unique problems of its own. In the tube, the screen and electron gun have to be made with great precision. Much of the system complexity, however, has been transferred from the tube to the associated circuits. A fundamental difficulty is to obtain an index signal from the tube which is unaffected by modulation of the electron beam. One solution to this problem is described in the paper.

621.397.621: 621.385.832

THE JOURNAL DIGEST | PAPERS PUBLISHED

In this monthly section are articles based on, or summaries of, papers published in the *Proceedings* of The Institution that have not been read at Institution meetings. The articles are on topics of some general interest and are written by the authors of the papers. The authors have been asked to make the articles, so far as possible, interesting and of appeal to electrical engineers who have no specialized knowledge of the topics covered. The contents of the articles develop the main points and conclusions of the papers, although their subject-matter is not necessarily confined to that of the original papers. The summaries are included primarily for reference. Reprints, price 2s., become available about two months after publication

Aerials

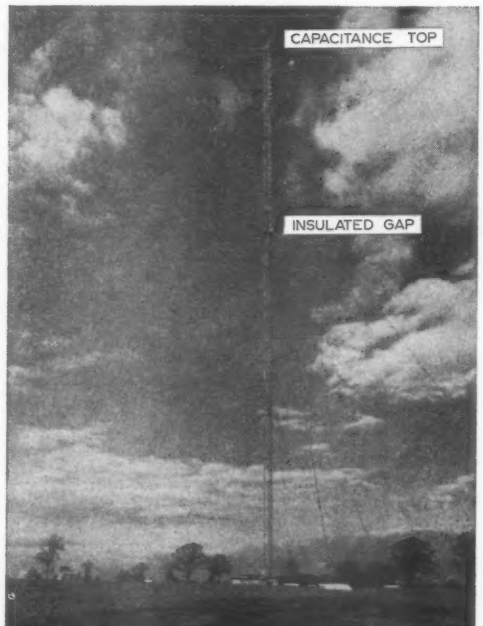
This brief article is based on a Review of Progress (paper 3663) with the above title by H. Page, M.Sc., Member. The paper is published this month in Part B of the Proceedings. The development of modern aerials from the days of Hertz is described in the review. The author is with the British Broadcasting Corporation.

THE first demonstration of the radiation of electromagnetic waves was given by Hertz in 1888. His aerial consisted of two spheres spaced 1m apart, connected by thin wires to a central gap across which sparks were induced by means of a large induction coil. Before the turn of the century, many scientists were pursuing the correspondence between electromagnetic and optical phenomena, using types of aerials (for instance, parabolic mirrors, horns and lenses) that have come into practical use only during the last 20 years.

Mast radiators

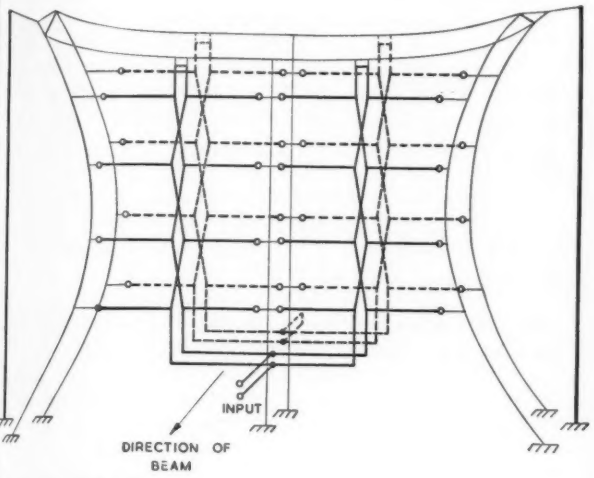
The principle of modulating the generator to transmit intelligence, demonstrated by Marconi in 1896, was another landmark in the rapidly developing science. His success focused attention on the potential importance of electromagnetic radiation for communication purposes and led to the attempt to achieve greater ranges by using large vertical aerials, often of great mechanical complexity. Broadcasting on medium wavelengths was inaugurated in the early 1920s. To cater for the high powers that later became available, mast radiators came into general use; the height is chosen to minimize fading, by reducing upward radiation towards the ionosphere. An anti-fading mast radiator is shown in Fig. 1.

The short-wave communication service inaugurated by the British Post Office in 1926 was made possible by the experiments carried out a decade earlier by Marconi and Franklin,

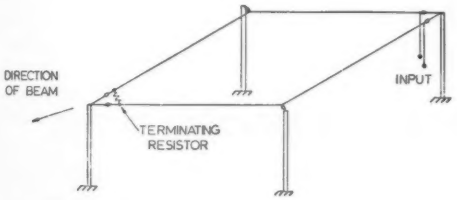


1 *Anti-fading mast radiator*
Height of mast is 229m; operating wavelength is 464m

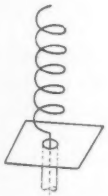
who successfully 'beamed' radiation by means of a reflector in the shape of a parabolic cylinder, composed of tuned rods. Nowadays, it is more convenient to achieve the same result by using co-planar arrays of energized elements (Fig. 2) or long-wire aerials (Fig. 3).



2 *Curtain array*



3 *Rhombic aerial*

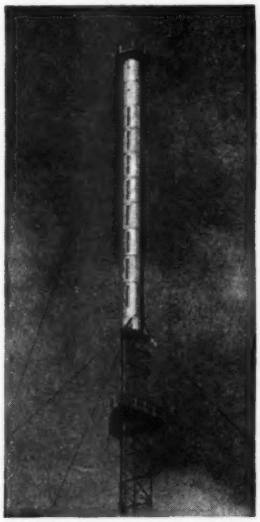


4 *Helical aerial*

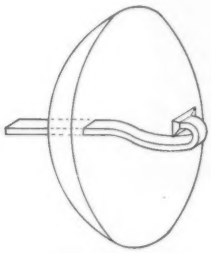
Progress in aerial design

Between the First and Second World Wars, steady progress was made in both the theory and the practice of aerial design. Shorter wavelengths were used as the longer-wave bands became either overcrowded or unsuitable for the application in view. At these short wavelengths, new forms of radiating elements are practicable and convenient for incorporating into arrays; examples are the helix (Fig. 4) and the slot. Fig. 5 shows a slot aerial used for the v.h.f. sound-broadcasting service in the United Kingdom.

For the centimetric and shorter wavelengths, optical techniques are convenient for achieving directional radiation characteristics. The aerials (which are generally used for point-to-point services, so that the beam of radiation must be as narrow as practicable) are essentially collimating devices, in which the approximately spherical wavefront of the primary radiator is transformed into a virtually plane wavefront by a secondary radiator. The two main classes are those that make use of the reflecting properties of metallic sheets (such as the parabolic reflector in Fig. 6, which is analogous to an optical reflecting telescope) and those that make use of the refracting properties of materials.



5 *Slot aerial used for sound broadcasting in the United Kingdom (87·5–95 Mc/s)*



6 *Paraboloid with rear feed*

Refracting aerials

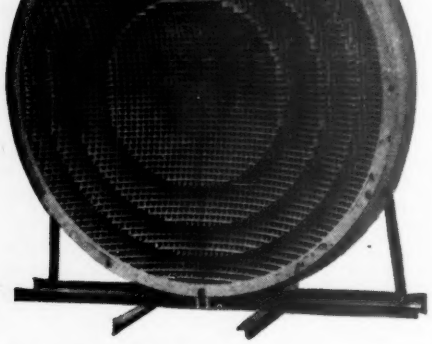
Refracting aerials fall into two classes. In the first, the velocity of propagation near the centre of the wavefront from the primary radiator is decreased by interposing a medium having a refractive index greater than unity; this is analogous in operation and similar in form to the optical lens. A suitable material is any low-loss dielectric that is amenable to machining or moulding, such as polystyrene. Such lenses work over a wide frequency band, but they are bulky and heavy, so that other arrangements are more attractive.

Kock showed that similar results could be achieved using an 'artificial dielectric', in which metallic particles spaced a small fraction of the wavelength apart were embedded in a low-loss material such as polystyrene foam. These media are lighter and therefore more convenient than homogeneous types, but they do not work over such a wide frequency band.

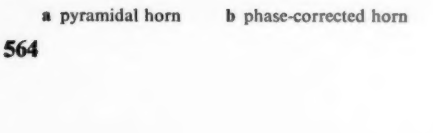
In the second type of refracting aerial, the phase velocity at the outer parts of the wavefront from the primary radiator is increased by interposing a medium having a refractive index less than unity; there is no corresponding optical analogy. One way of achieving this result is to use a series of parallel metal plates, with edges in the direction of the incident electric force (Fig. 7), the width of the plates increasing towards the edge of the lens. In practice, the width of any plate can be reduced, provided that the combined free

space and guided path is decreased by an integral number of wavelengths. This gives the 'zoned' shape shown in Fig. 8 and considerably reduces the bulk and weight of the lens. Parallel-plate lenses can be designed to work over only a narrow frequency band.

7 *Cross-section of a parallel-plate lens*



8 *Zoned parallel-plate lens*



9 *Metallic horn*

a pyramidal horn **b** phase-corrected horn

Horn aerials

Another simple means of achieving a directional aerial is to flare out the end of the waveguide into a horn of the required aperture (Fig. 9a). The flare must be sufficiently gradual to make the phase reasonably uniform over the radiating aperture, but the horn would then be inconveniently large. If the flare length is reduced, the difficulty that the path from the throat to the centre of the radiating aperture is shorter than that to the edge can be overcome by adding a series of parallel metallic plates as shown in Fig. 9b. The phase-corrected horn may be regarded as a parallel-plate lens in association with a primary source whose radiation is guided by the walls of the horn.

10 *Horn reflector*

In an alternative arrangement, shown in Fig. 10, the phase may be corrected by capping the horn with a sector of a paraboloid of revolution, with the apex of the horn at the focus. This arrangement has the great advantage of working over a wide frequency band, and it is consequently coming into common use on fixed centimetric-wave links. 621.396.67

Speed-changing induction motors

A summary of a Utilization Section paper (3487) with the above title by Prof. G. H. Rawcliffe, M.A., D.Sc., Member, and W. Fong, Ph.D., Associate Member. The paper will be published in Part A of the Proceedings. Prof. Rawcliffe is Professor of Electrical Engineering, and Dr. Fong is in the Department of Electrical Engineering, University of Bristol.

Previous authors when discussing pole-amplitude modulation have described methods of increasing the pole number and reducing the speed by modulation. The reciprocal possibility has already been pointed out, and it has now been found that, in some conditions, it is better to use modulation to reduce the pole number and increase the speed.

The particular form of modulation used in the examples described gives exceptionally good performance. Test results are recorded for a small laboratory machine and for a very large machine made by an industrial company, both for 10/8 poles and both being very successful. The general conclusions are reached that, for many purposes, a 10/8-pole motor is to be preferred to an 8/10-pole one and that modulation to reduce the pole number of an electrical machine has important industrial possibilities. 621.313.333 : 621.316.718

Design basis for silicon controlled inverters

A summary of an Electronics and Communications Section paper (3642) 'A design basis for silicon controlled rectifier parallel inverters' by R. H. Murphy, B.Sc.(Eng.), Graduate, and K. P. P. Nambiar, M.Sc., Associate Member. The paper is published this month in Part B of the Proceedings. The authors are with Transitron Electronic Ltd.

THE operation of the silicon controlled rectifier in the basic form of parallel-inverter circuits with resistive loads is investigated, and analysis is carried out to determine the conditions for optimum performance. Two fundamental parameters in terms of time-constants are introduced, one relating to the ballast inductance and the other to the commutating capacitance, as opposed to the method of defining design parameters in terms of a required triggering period hitherto employed in analysing thyratron circuits.

The analysis shows that the basic circuit has three main modes of operation, two of which are undesirable. Within the range of the desirable mode, square-wave and sine-wave operations are found to be feasible, and a procedure is given for determining the optimum triggering points in terms of time-constants.

Expressions are derived for the maximum repetition rates for the generation of both types of waveform in terms of relevant time-constants and turn-off times of the silicon controlled rectifiers. With currently available high-current silicon controlled rectifiers, repetition rates of about 6kc/s for square-wave operation and 12kc/s for sine-wave operation are found to be readily obtainable. With low-current diffused types, the corresponding repetition rates would be about 35 and 70kc/s respectively. The complete design procedure is illustrated by applying the analytical results to the practical design of a d.c.–d.c. convertor, which is essentially an inverter followed by a bridge-rectifier filter unit. 621.314.58 : 621.382.233

The interferometer in h.f. direction-finding

A summary of an Electronics and Communications Section paper (3678) 'The application of the interferometer to h.f. direction-finding' by C. W. McLeish, M.Sc., and N. Burtnyk, B.Sc. The paper is published this month in Part B of the Proceedings. The authors are in the Radio and Electrical Engineering Division of the National Research Council, Canada.

THE measured performance of an interferometer system for direction-finding in the h.f. band is described. A considerable reduction in bearing error compared with that of a narrow-aperture (Adcock) system is obtained in the presence of ground reradiators and fluctuating-wave interference fields. A standard deviation of about 1·2° has been obtained with a 400ft interferometer on sky-wave transmissions in the 5–25Mc/s band. 621.396.93 : 621.396.67

Analysis of a cylindrical cavity

A summary of an Electronics and Communications Section paper (3684) 'An analysis of a cylindrical cavity with radial vanes' by A. Singh, Ph.D., and R. A. Rao. The paper is published this month in Part B of the Proceedings. Dr. Singh is Deputy Director-in-Charge of, and Mr. Rao was formerly at, the Central Electronics Engineering Research Institute, Pilani, India. Mr. Rao is now in the Department of Electrical Engineering, University of California, U.S.A.

AN analysis is given for evaluating the resonant frequencies of modes of lower orders in a cylindrical cavity having radial vanes. The procedure involves the use of variational methods for obtaining successively better approximations to the resonant frequencies and the field configurations. The trial field is chosen to satisfy the boundary conditions at the vanes. This makes the procedure valid even when the perturbations introduced by the vanes are large. Good agreement is obtained between computed and experimentally observed resonant frequencies for varying degrees of penetration by a pair of vanes, the change in frequency produced by the vanes being up to 28%. 621.373.14

Pilot-wire differential protection systems

A summary of a Supply Section paper (3645) 'The fundamental characteristics of pilot-wire differential protection systems' by J. Rushton, Associate Member. The paper will be published in Part A of the Proceedings. The author is with the Central Electricity Generating Board (South Wales Division).

IN the design of pilot-wire protection systems the pilot circuit is usually considered to be either purely resistive or completely balanced and able to transmit information simultaneously from end to end. Characteristics are given for long practical circuits showing that these are invariably unsymmetrical owing to their heterogeneous composition, and it is shown that the change in pilot-circuit input admittance due to remote-end voltage variation gives a reliable indication of design parameters.

A locus diagram is given for pilot-circuit admittance on which the relay operating characteristics can be superimposed, giving complete design information for the protection scheme. By a change of axis this diagram can be redrawn in terms of power-system input currents to the relay system, showing the performance of the relays at both ends of the line.

Consideration is given to the design of practical protection schemes using the longest pilot circuits, which are treated as completely unsymmetrical networks. The effect of the non-linearities in the voltage-limiting circuits is also discussed.

A design technique is illustrated that enables the protective-scheme characteristics to be predicted and verified by simple tests. Practical limits and limitations inherent in the use of rented telephone-type circuits are discussed briefly, since these exert much influence on practical scheme design. 621.316.925.2

Choosing transformer ratio-arm bridges

A summary of a Measurement and Control Section paper (3646) with the above title by W. H. P. Leslie, B.Sc., Member. The paper is published this month in Part B of the Proceedings. The author is at the National Engineering Laboratory, Department of Scientific and Industrial Research.

RECENT publications on transformer ratio-arm bridges have given a false impression of their operating principles. The allocation of shunt and leakage inductance to each winding of a toroidal 2- or 3-winding transformer is first considered. This is then applied to the analysis of bridges for particular practical applications proposed by Lynch, Thompson, the present author and Karo. The balance conditions are compared, in the presence of shunt stray impedance, and it is shown that three of the bridges have each their most suitable applications. This does not seem likely for the last type. 621.317.733

An automatic electronic Nyquist plotter

A summary of a Measurement and Control Section paper (3688) with the above title by H. J. Fraser, Associate Member, and W. V. P. Reece. The paper is published this month in Part B of the Proceedings. Mr. Fraser is with the Australian Atomic Energy Commission, and Mr. Reece is with the Sperry Gyroscope Co., Salisbury, S. Australia.

THE instrument described is designed to plot automatically in polar co-ordinates the transfer functions of electrical networks or servo-systems over the frequency range 0·2–200c/s. It consists basically of:

(i) A variable-frequency resistance-tuned oscillator that delivers a constant voltage to the system under test
(ii) A narrow-band-pass *RC* filter tracked with the oscillator to eliminate noise from the output of the system under test
(iii) An *RC* 90°-phase-shifting circuit tracked with the oscillator to obtain a radial measure of output voltage on an oscilloscope
(iv) A 12in. cathode-ray display unit with pulse brightening, which shows output voltage, phase and frequency in the form of a Nyquist plot as the frequency of the oscillator is varied.

Eight ganged 10-turn helical resistors are used for tracking the oscillator, filter and 90°-phase-shifting circuits.

Owing to tracking errors, the filter results in maximum inaccuracies in the plot of ±0·4dB amplitude and ±2° phase shift. The bandwidth of the filter is 20% of the operating frequency. 621.317.77 : 621—52

Silicon transistors and circuit design

A summary of a Measurement and Control Section paper (3671) 'Some advantages of silicon transistors in circuit design' by M. K. McPhun, B.Sc.(Eng.), Graduate. The paper is published this month in Part B of the Proceedings. The author was formerly with the United Kingdom Atomic Energy Authority (Development and Engineering Group) and is now at the Central Electricity Research Laboratories.

AFTER transistors had been used for industrial instrumentation within the Development and Engineering Group of the United Kingdom Atomic Energy Authority for some years, silicon transistors were adopted for general-purpose use, as they were expected to be more reliable than germanium transistors. It has since become apparent that they possess more advantages over germanium transistors than is generally recognized, or was thought at the time of their adoption. For example, direct coupling of transistor circuits is facilitated and the number of components required may be much reduced; the use of electrolytic capacitors may be avoided.

The author compares the performance of silicon and germanium transistors from the viewpoint of the circuit designer; physical origins of their characteristics are not discussed. A range of circuits which take advantage of the characteristics peculiar to silicon transistors is described. The circuits are for direct-coupled amplifiers, current amplifiers for small signals, switching applications and multivibrators with long periods. 621.382.3

THE JOURNAL DIGEST | IN THE PROCEEDINGS

The date in italics is that of the Journal review, special article or synopsis. Where given, the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (AUGUST 1961)

See the Journal for August 1961, p. 518

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (SEPTEMBER 1961)

H. PAGE, M.SC. PAPER 3663E **Aerials** (Review of progress) *September 1961*

D. WOODS. LECTURE 3691M **Precision instruments for coaxial line measurements up to 4Gc/s** *August 1961, p. 532 (report)*

C. W. McLEISH, M.SC., *and* N. BURTNYK, B.SC. PAPER 3678E **The application of the interferometer to h.f. direction-finding** *September 1961*

W. T. J. ATKINS, B.SC.(ENG.) **Theory of time-delay networks** (communication)

F. A. BENSON, D.ENG., PH.D., *and* G. P. BURDETT, B.ENG. PAPER 3420E, JANUARY 1961 **Comparison of argon, krypton and xenon as admixtures in neon glow-discharge reference tubes** *July 1961*

R. GRAHAM, M.ENG., J. W. H. JUSTICE *and* J. K. OXENHAM, M.A. PAPER 3468E, FEBRUARY 1961 **Progress report on the development of a photoelectric beam-index colour-television tube and system** *September 1961*

J. L. DOUCE, M.SC., PH.D., *and* B. G. LEARY, B.E. PAPER 3612M **A random pulse generator with variable mean rate** *August 1961*

B. P. BHATTACHARYYA, B.E., C.E., M.E. PAPER 3568M **Describing-function expressions for sine-type functional non-linearity in feedback control systems** *June 1961*

H. J. FRASER *and* W. V. P. REECE. PAPER 3688M **An automatic electronic Nyquist plotter** *September 1961*

W. H. P. LESLIE, B.SC. PAPER 3646M **Choosing transformer ratio-arm bridges** *September 1961*

N. KARAYIANIS *and* C. A. MORRISON. **An analysis of the travelling-wave cavity** (communication)

A. SINGH, PH.D., *and* R. A. RAO. PAPER 3684E **An analysis of a cylindrical cavity with radial vanes** *September 1961*

R. H. MURPHY, B.SC.(ENG.), *and* K. P. P. NAMBIAR, M.SC. PAPER 3642E **A design basis for silicon controlled rectifier parallel inverters** *September 1961*

G. M. ETTINGER, PH.D. PAPER 3610E **Some circuit applications of avalanche devices** *July 1961*

M. K. McPHUN, B.SC.(ENG.). PAPER 3671M **Some advantages of silicon transistors in circuit design** *September 1961*

PART C. MONOGRAPHS (SEPTEMBER 1961)

N. C. ENSLIN, PH.D. 422U, DECEMBER 1960 **Interconnected rotor induction motors** *December 1960*

ZE'EV BONENN, B.SC. 423M, DECEMBER 1960 **Frequency response of feedback relay amplifiers** *December 1960*

PROF. G. BIORCI. 424E, DECEMBER 1960 **Sign matrices and realizability of conductance matrices** *December 1960*

J. ZAWELS, PH.D. 425E, JANUARY 1961 **Travelling-wave analysis of generalized networks** *January 1961*

R. JACKSON, M.A. 426M, JANUARY 1961 **Optimum sampled-data control** *January 1961*

C. E. WEBB, B.SC.(ENG.). 427M, JANUARY 1961 **The stability of permanent magnets** *January 1961*

R. ONODERA. 428E, FEBRUARY 1961 **Topological synthesis of non-reciprocal resistance networks** *February 1961*

K. THARMALINGAM, B.A., B.SC. 429E, FEBRUARY 1961 **The impulse response of a number of identical circuits in cascade** *February 1961*

A. J. BADEN FULLER, M.A. 430E, FEBRUARY 1961 **Microwave propagation through round waveguide partially filled with ferrite** *February 1961*

PROF. H. E. M. BARLOW, B.SC.(ENG.), PH.D. 431E, FEBRUARY 1961 **Microwave Hall effect and the accompanying rotation of the plane of polarization** *February 1961*

N. REAM, B.A. 432M, FEBRUARY 1961 **A method of calculating the transfer functions of ladder networks** *February 1961*

L. LEWIN. 433E, FEBRUARY 1961 **The part played by surface waves on the reflection at a ferrite boundary** *February 1961*

Z. GODZIŃSKI. 434E, MARCH 1961 **The surface impedance concept and the structure of radio waves over real earth** *March 1961*

C. B. NEWPORT, PH.D., *and* D. A. BELL, M.A., PH.D. 435M, MARCH 1961 **The analysis of non-linear resonant circuits** *March 1961*

T. BERCELI, DR.-ING. 436E, MARCH 1961 **Design of cylindrical surface waveguides with dielectric and magnetic coating** *March 1961*

P. J. B. CLARRICOATS, B.SC.(ENG.), PH.D. 437E, APRIL 1961 **A broadband waveguide junction containing dielectric** *April 1961*

K. C. MUKHERJI, B.E., PH.D. 438U, APRIL 1961 **Certain approaches to electromagnetic field problems pertaining to dynamo-electric machines** *April 1961*

R. J. KAVANAGH, B.SC., M.A.SC., PH.D. 439M, APRIL 1961 **A note on optimum linear multivariable filters** *April 1961*

I. A. BLACK, B.SC.(ENG.), PH.D. 440S, APRIL 1961 **Factors affecting the behaviour of an electric arc under transient conditions** *April 1961*

D. P. R. PETRIE, M.SC., R. BAILEY, B.SC., D. G. KEITH-WALKER, B.SC.(ENG.), H. LONGLEY, B.SC., *and* D. R. CHICK, D.SC. 441M, APRIL 1961 **An experimental proton linear accelerator using a helix structure** *April 1961*

B. ROGAL, B.SC.(ENG.), *and* PROF. A. L. CULLEN, O.B.E., PH.D. 442E, MAY 1961 **Wide-band coupling systems between a waveguide and a transmission line** *May 1961*

G. H. METSON, M.C., D.SC., PH.D., M.SC., B.SC.(ENG.). 443E, MAY 1961 **The conductivity of oxide cathodes. Part 10—Spontaneous generation of negative ions** *May 1961*

G. H. METSON, M.C., D.SC., PH.D., M.SC., B.SC.(ENG.), *and* H. BATEY. 444E, MAY 1961 **The conductivity of oxide cathodes. Part 11—Thermal stability of the alkaline-earth oxides** *May 1961*

LEO YOUNG, DR.ENG., M.A., M.S. 445, MAY 1961 **Transitional electrical units** *May 1961*

PROF. F. BRAILSFORD, PH.D., *and* J. M. BURGESS, B.SC.(ENG.). 446M, MAY 1961 **Internal waveform distortion in silicon-iron laminations for magnetization at 50c/s** *May 1961*

A. E. GUILE, PH.D., B.SC.(ENG.), T. J. LEWIS, PH.D., M.SC., B.SC.(ENG.), *and* P. E. SECKER, PH.D., B.SC.(ENG.). 447S, MAY 1961 **The motion of cold-cathode arcs in magnetic fields** *May 1961*

P. A. W. WALKER, B.ENG., *and* A. S. ALDRED, M.SC., PH.D. 448S, MAY 1961 **Frequency-response analysis of displacement governing in synchronous power systems** *May 1961*

COLIN ADAMSON, D.SC., M.SC.(ENG.), *and* M. VISESHAKUL, M.SC.TECH., PH.D. 449S, JUNE 1961 **Analytical determination of the characteristics of enclosed and oil-immersed fuses** *June 1961*

PROF. A. L. CULLEN, O.B.E., PH.D., *and* J. A. STANIFORTH, PH.D. 450E, JUNE 1961 **The launching of surface waves by an end-fire array of slots** *June 1961*

P. J. B. CLARRICOATS, B.SC.(ENG.), PH.D. 451E, JUNE 1961 **Backward waves in waveguides containing dielectric** *June 1961*

T. GLUCHAROFF, M.E. 452M, JUNE 1961 **The relation between discrete periodic inputs, the transfer function and the transient response of a system** *June 1961*

D. A. JONES, B.SC., PH.D., *and* W. S. LEUNG, B.SC.(ENG.), PH.D. 453U, JUNE 1961 **A theoretical and analogue approach to stray eddy-current loss in laminated magnetic cores** *June 1961*

M. H. WALSHAW, B.SC.(ENG.), *and* J. W. LYNN, M.SC., PH.D. 454S, JUNE 1961 **A hunting analysis of a permanent-magnet alternator and a synchronous motor** *June 1961*

Communicated discussion on **Orthogonal codes**

Communicated discussion on **Calculation of the current in non-linear surge-current-generator circuits**

Communicated discussion on **Eddy-current effects in rectangular ferromagnetic rods**

Communicated discussion on **Electric and magnetic images**

Communicated discussion on **Optimum combination of pulse shape and filter to produce a signal peak upon a noise background**

Communicated discussion on **An analytical review of power-system frequency, time and tie-line control**

Communicated discussion on **Numerical evaluation of inductance and a.c. resistance**

Communicated discussion on **Frequency spectrum distortion of random signals in non-linear feedback systems**

Communicated discussion on **The stability of permanent magnets**

Communicated discussion on **Matrix analysis of constrained networks**

THE JOURNAL DIGEST | MONOGRAPHS

Monographs are first published individually, price 2s., and are republished later in Part C of the Proceedings of The Institution. As soon as the separate monographs are available, summaries are given in this feature.

Applications quoting the serial number of the monographs as well as the author's name, and accompanied by a remittance, should be addressed to the Secretary of The Institution.

For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

An invariant stability factor and its physical significance

Monograph 468E

S. VENKATESWARAN, M.A.

RELATIONSHIPS between the maximum power gain and the internal loop gain of a general linear two-port network are developed. A new stability factor is defined from the maximum-gain potentiality of the network without external feedback, and is physically identifiable as the modulus of the internal loop loss (the inverse of loop gain) at maximum available power gain, where this is finite. Several theorems on this loop gain show the relationships between the new stability factor, Stern's stability factor, and the author's 'performance factor'.

Though the earlier factors may be obtained by constraints on the internal loop gain, they are shown not to be exactly related to the internal loop gain of the two-port network at maximum power gain; also, they are not exact invariants in matrix environments save in exceptional cases.

The new stability factor is an exact invariant for all its values in the possible matrix environments, demarcates the regions of potential instability and absolute stability, and is directly related to the maximum available power gain of the two-port network, when this gain is finite.

Pole-entry flux pulsations

Monograph 469U

K. J. BINNS, B.SC.

THE rapid changes in flux distribution that occur as a slotted armature moves relative to a pole corner give rise to losses both in the copper and in the iron. These flux pulsations can have a considerable effect on the performance of both a.c. and d.c. machines.

The author presents an accurate determination of the field of a slot passing under a rectangular pole corner, and the flux changes under relative motion are calculated over the range of dimensions of practical interest. The flux entering the armature slots is calculated and compared with values measured by search coils; the two sets of results are in close agreement. The effect of the slot width on the induced e.m.f. in the armature conductors is commonly ignored in design work. However, the effect is shown to be appreciable. Finally, the variation in the forces acting on the armature teeth is determined; this quantity is exceedingly difficult to obtain experimentally.

The signal/noise gain of ideal receiving arrays

Monograph 470E

V. G. WELSBY, PH.D.

A STUDY is made of the theoretical signal/noise gain of an ideal strip transducer; this gain is the actual signal/noise ratio compared with that for a 'point' receiver (i.e. one whose dimensions are small compared with the wavelength at the lowest significant frequency). The results are not restricted to narrow-band systems and relate generally to noise fields that may be non-isotropic and have non-uniform frequency spectra.

The theory is used to investigate the correlation between the noise outputs of the various sections of a subdivided transducer, and it is shown that, at least in the narrow-band case, the usual assumption of negligible correlation is generally justified in practice. Multiplicative systems are also considered. In certain circumstances the over-all signal/noise ratio of such a system may be better than that of either of its component groups.

The results obtained are also generally applicable to ideal radio receiving arrays.

THE JOURNAL DIGEST | PAPER TO BE READ

Papers accepted for reading at meetings and eventual publication in the Proceedings of The Institution are first published individually. The separate papers are supplied free of charge, and as soon as they become available they are summarized in this feature.

Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint, as this is the final and correct version and includes the discussion. Reprints become available, price 2s., about two months after the appearance of the paper in the Proceedings.

Applications quoting the serial number of the paper or reprint as well as the author's name, and accompanied by a remittance where appropriate, should be addressed to the Secretary of The Institution. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

The use of analogue computers in predicting the space-time behaviour of nuclear reactors

Paper 3704M, *Part A*

R. W. HOCKNEY, M.A., *and* T. O. JEFFRIES, M.A., D.PHIL.

THE study of the dynamic behaviour of a complex system such as a nuclear reactor is conveniently performed on an analogue computer. The equations to be solved are described, and three approximations suitable in different circumstances are given. The application of one of these methods to an investigation of spatial instabilities is presented.

To be read on the 24th October 1961

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

ANDERS CHRISTIAN MADSEN ANDERSEN

Anders Christian Madsen Andersen, a former engineer-in-chief of the Great Northern Telegraph Co. (of Denmark), who was born at Thisted, Denmark, on the 20th October 1875 died in Copenhagen on the 28th January 1961.

He joined the Great Northern Telegraph in 1896, having received a public-school education at Thisted; and, after serving in many of the company's branches in Europe, Siberia, China and Japan and in cable ships, he was appointed engineer-in-chief, Far East, in 1915. He retired in 1928. He will be remembered as an engineer of broad knowledge and wide practical experience and of very sound judgment.

He was popular with all who came into contact with him in business, and he made many friends on account of his great sincerity. Besides being a life-member of the Shanghai Club, he was a member of several other clubs in the Far East, and he was often called on to serve on boards and committees. In his younger days he was a keen all-round sportsman; in his later years he limited his sporting activities to golf.

He was decorated by the Japanese Government with the order of the Holy Treasure and by the Chinese Government with the order of the Golden Crop.

He joined The Institution as a Member in 1917.

WILLIAM ALFRED BARNETT

William Alfred Barnett who died on the 4th February 1961 was born on the 16th July 1887 and was educated part-time at Barry County Technical College while serving an apprenticeship with John Shearman and Co., Barry, Glamorgan. He received further practical experience at the Cwmbran and Bridgend stations of South Wales Electric Power Distribution Co. before joining Gillingham Corporation as charge engineer in 1907.

In 1909 he joined the civilian staff at Chatham dockyard as supervisor and a year later became charge engineer with the Midland Electric Corporation for Power Distribution, Tipton, Staffordshire. In 1929 he was appointed boiler-house superintendent. In 1932 he transferred in the same position to Ironbridge power station, with the West Midland Joint Electricity Authority, and in 1935 was promoted to assistant resident engineer, also at Ironbridge. In 1942 he became chief generating engineer, which position he held until his retirement in 1947.

Colleagues and subordinates enjoyed working with him. Though he took no office, he was a keen member of the sports and social club, but, apart from an occasional game of snooker, it could be said that his hobby was his work. He is survived by his widow and two daughters.

He joined The Institution as an Associate Member in 1912 and was elected a Member in 1943. G. F. P.

THOMAS BROWNLIE DOIG

Thomas Brownlie Doig who died suddenly on the 4th May 1961 was an engineer of wide knowledge and experience extending far beyond his immediate sphere of electrical engineering. Of modest disposition, his personality was one that made a favourable and lasting impression on those with whom he came into contact.

Born in Edinburgh on the 7th June 1907, he was educated at George Heriot's School and at Heriot-Watt College and received his early training with Metropolitan Vickers Electrical Co., after which he served with Bruce Peebles and Co., Edinburgh, with Harland Engineering Co., Alloa, and with Lancashire Dynamo and Crypto Ltd., Manchester.

At the time of his death he was with Powell Duffryn Technical Services Ltd., London, following several years as manager of the export machinery department of Dodwell and Co. He was also for a period engineer and buyer in Manchester for the H. A. Roberts Company of Buenos Aires.

During the Second World War he served in the United Kingdom and South-East Asia Command. He was demobilized in 1946 with the rank of captain in the Indian Electrical and Mechanical Engineers, 5th Indian Division.

He was a devoted member of the Presbyterian Church and of the Boy Scouts Association, which he joined as a wolf cub as long ago as 1916, remaining an active member for the rest of his life. He is survived by his widow and two sons.

He joined The Institution as a Student in 1929 and was elected a Graduate in 1936, an Associate Member in 1944 and a Member in 1953. R. S.

MOSTYN RANDAL GARDNER

Mostyn Randal Gardner who died on the 12th October 1960 was born on the 9th January 1878. He was educated at Skinners' Boys' School, Tunbridge Wells, and at Tonbridge School, and received his electrical engineering education at Finsbury Technical College. He received practical experience with Edison and Swan Electric Co., Ponders End.

He commenced his career as an electrical engineer with the Peninsular and Oriental Steam Navigation Co. in 1899. He then joined the Central London Railway Co. as a substation and signal engineer and in 1913 became the assistant signal engineer with the Underground Railway Co., responsible for all the electric lighting, telephones and similar fixed electrical equipment.

During the 1914–18 War he served in H.M.S. *Ebro* as an engineer sub-lieutenant. On demobilization he became assistant engineer in the electrical engineering department of the Admiralty.

He joined Westinghouse Brake and Signal Co. in 1921 in the electrical engineering department and worked on the very specialized subject of preparing tenders for electrical signalling contracts. He was appointed in 1927 as their resident engineer in Brazil, responsible for installing electrical signalling equipment on some of the railway lines. He returned to the United Kingdom in 1930, where he was responsible as resident engineer for the installation of a number of electrical signalling contracts on British railways. He joined the head-office staff of Westinghouse in 1935 and remained there until he resigned in 1938.

He was a first-class electrical engineer, very thorough and reliable in all his work, and was an extremely likeable personality, with the Irish sense of humour. He played a good game of tennis, was a keen gardener and was very interested in motor-cars.

He joined The Institution as a Student in 1897 and was elected an Associate in 1901, an Associate Member in 1912 and a Member in 1920. He was awarded a Student premium in 1899 jointly with R. P. Howgrave-Graham for their paper entitled 'The synchronizing of alternators'. T. J. A.

ALFRED SAMUEL ABBISS JOHNSON

Alfred Samuel Abbiss Johnson who was born in Liverpool on the 18th May 1879 died at Reigate on the 23rd December 1958. He was educated privately in Liverpool and joined the Post Office there in 1895 as a telegraphist and passed through various grades to become an 'old style' assistant engineer in 1909. During the First World War he served with the Royal Engineers as a lieutenant. As a member of the telephone branch of the Engineer-in-Chief's Office, he became actively engaged in the many problems associated with the early days of automation of the telephone service, including cost studies to determine which of the larger manual telephone exchanges ought to be converted to automatic working for economic reasons.

He was promoted to an 'old style' executive engineer in 1925, still in the telephone branch, and was responsible for the trunking, calculation of switching quantities, design and specification work for all automatic exchange schemes in the Provinces. Under reorganization in 1931, the trunking-exchange design work was transferred to the equipment branch of the Engineer-in-Chief's Office, and he took charge of this work on promotion to assistant staff engineer.

He transferred to the London Engineering District in 1936, where he was responsible for the design of exchanges and all accommodation problems affecting London until he retired in 1939.

During his official career he took a lively interest in all matters appertaining to technical training, and this was exemplified in his interest in the City and Guilds of London Institute, for which he was an examiner in telephony subjects from 1934 to 1946.

Obituary (continued)

He was a keen family man, with two sons and a daughter, both sons being Post Office servants. In his younger days he was an enthusiastic tennis player, while in later years he turned to bowls and colour photography. He was a good speaker and had a good fund of anecdotes, but he will be remembered most of all by his colleagues for his kindly nature and willingness to help anyone.

He joined The Institution as an Associate Member in 1921 and was elected a Member in 1933. G. S. B.

FRANK LONGWORTH

Frank Longworth, B.SC.TECH., who died on the 22nd January 1961 was born on the 2nd February 1904. He was educated at Hindley and Abram Grammar School, Hindley, Lancashire. After taking his degree at the Manchester College of Technology in 1925, he spent his early years in industry with Henry Simon Ltd., Stockport, and in 1941 became general manager for John Wood and Sons, Wigan. In 1944 he joined, for a short time, the family coal-mine business in Wigan before becoming chief electrical and mechanical engineer with Millom and Askam Hematite Iron Co.

In 1952 he joined the British Ropeway Engineering Co. as chief engineer and was responsible for the electrical equipment of many large cableways and ropeways in New Zealand, India, Canada, Jamaica, Turkey, Iran, South America and Sierra Leone, as well as at home. He brought much original thought to solving the problems associated with cableways, ropeways and chair-lifts and travelled to New Zealand, South America, France and Germany. His main interest was his work, and he would frequently spend his evenings wrestling with particularly difficult problems.

He had not enjoyed good health for a few years past and became seriously ill while on a visit to a ropeway high in the Andes, when the altitude affected his heart. He was a quiet kindly man, who was happiest with his family and grandchildren, and latterly found pleasure in cinematography.

In his dealings with his business associates he was a man of the highest integrity and was known for his conscientious and meticulous outlook. He will be sadly missed by his many friends in industry.

He is survived by his widow and three sons, of whom two are engineers and the youngest is at Sheffield University.

He joined The Institution as a Student in 1923 and was elected an Associate Member in 1933 and a Member in 1957. He was also a member of the Royal Institution. A. D. J. R.

DAVID KIRK McCLEERY

Instr.-Cmdr. David Kirk McCleery, M.SC., who died on the 18th April 1961 was born on the 27th March 1904. He was educated at Worksop College, Nottinghamshire, at Hurstpierpoint College, Sussex, at Woolwich Polytechnic, and at the Royal Naval College, Greenwich, and received practical training with the Telegraph Construction and Maintenance Co.

At the time of his death, he was a lecturer in the department of electrical engineering of the College of Science and Technology, Manchester. Before joining the college, he had been senior lecturer in electrical engineering at the Royal Naval College, Greenwich. This followed appointments in the Royal Navy, afloat and ashore, with service in H.M. ships, including *Shropshire*, *Nelson*, *Rodney*, *King Alfred*, *Glasgow*, *Sheffield*, *Anson*, and *Vanguard*.

His sudden death saddened not only his immediate colleagues in the electrical engineering department but many others in the college and in a wider field. He took an active part in the corporate life of the college, and many of his colleagues have occasion to be grateful for his friendship and his ready help and valuable advice.

Apart from his normal duties as a member of the college staff, he served as assistant editor of the *Bulletin of Electrical Engineering Education*. He also took a particular interest in the problems of student selection and admission: his interest was reflected in his concern for the progress of students, particularly in the early stages of their university course.

He joined The Institution as an Associate Member in 1932 and was elected a Member in 1948. He was also a Fellow of the Institute of Physics. E. B.

WILL MOORE

Will Moore, M.B.E., who died on the 12th March 1961 was born at Nottingham on the 21st December 1884. He was educated at a local secondary school, joined the Nottingham Corporation Electricity Department as an office junior in 1900, and received his technical education part-time at Nottingham University College. In 1905 he became engineer-in-charge of the new Eastcroft destructor station, one of the first stations to generate electricity from domestic refuse. He was promoted to engineer-in-charge at St. Ann's power station in 1910, where some 4MW of d.c. generators only were installed at the time.

In 1914 he was appointed mains engineer to the undertaking and in 1918 inaugurated the first a.c. distribution in the city. Owing to wartime restrictions, this a.c. supply was initially provided from inverted convertors.

He was promoted to mains superintendent in 1930 and to distribution superintendent in 1945. In the latter position he was responsible for the design and control of all substations, a.c. static, rectifier and convertor.

On nationalization in 1948 he was appointed engineer to the Nottingham Sub-Area of the East Midlands Electricity Board, a position he held until his retirement in 1950. In 1949, on completion of 50 years' service with the Nottingham undertaking, he was presented with an illuminated address by the East Midlands Electricity Board for 'unflagging energy and zeal, as well as for charm of manner and high personal standards which have won the lasting regard of all your colleagues', and in the same year he was appointed a Member of the Order of the British Empire for 'distinguished services to the electricity supply industry'.

His hobbies were motoring and foreign travel, particularly by sea, and both before and after his retirement he visited many parts of the world purely for pleasure. He is survived by his widow and a married daughter.

He joined The Institution as an Associate Member in 1911 and was elected a Member in 1934. He served on the East Midland Sub-Centre Committee in 1945–46. G. H. L.

JOHN DAVID MORGAN

John David Morgan, D.SC., senior partner in Marks and Clerk, patent agents, who died on the 19th March 1961 was born on the 2nd April 1879 in Chester. He was educated at Aston Higher-Grade School, Birmingham, to the age of 13 and then commenced an apprenticeship with Heenan and Froude. He continued studying part-time at Birmingham Municipal Technical School and by 1903 obtained his matriculation and passed the examinations for The Institution of Civil Engineers and the Institute of Patent Agents. He joined Marks and Clerk as a junior draughtsman in 1896, and from then onwards his professional work was linked with that firm, in which he became a partner on the death of E. C. R. Marks in 1927.

He will be best remembered for his scientific work in a small laboratory in Temple Street, Birmingham, and later at his home. This work, carried out first in conjunction with Dr. Wheeler of Sheffield University and later with Prof. Taylor-Jones, covered a special study of the principles of ignition of gaseous mixtures. The results of his work and the conclusions reached did much to clarify knowledge of the subject and are now universally accepted. Arising from the work he received successively the B.Sc., M.Sc., and D.Sc. degrees of the University of Birmingham, the latter in 1925.

Although in later years failing health confined him to his home, he still carried out his work as patent adviser until the end of January 1961, having served for 65 years with the firm.

As a patent adviser he impressed all who met him by his logical mind and powers of analysis, but his friends keenly appreciated his outlook on life and his belief in the possibility of a close relationship between science, philosophy and religion. He took an active interest in the Congregational Church and was a life-long member at Soho Hill, Birmingham. He is survived by his widow and two sons, both engineers in Birmingham.

He joined The Institution as an Associate in 1909 and was elected an Associate Member in 1914 and a Member in 1918. He served as honorary secretary of Birmingham Local Centre from 1913 to 1922 and as vice-chairman in 1922–23, and as chairman in 1923–24 of the South Midland Centre. Two of his papers, entitled 'Dynamos for motor road-vehicle lighting' and 'Notes on the ignition of explosive gas mixtures by electric sparks', were published in the *Journal* in 1914 and in 1916 respectively. E. A. W.

HUGH MARSHALL NIMMO

Hugh Marshall Nimmo, M.SC., B.E., who was born in Dunedin, New Zealand, on the 14th August 1904 died on the 28th May 1960. He was educated at Otago Boys' High School and at Otago University, Dunedin.

After obtaining his degrees from the University of New Zealand, he completed a tester's course with British Thomson-Houston Co., Rugby, from 1929 to 1931. In 1934 he became an electrical engineer with Ackton Hall Collieries Ltd., Pontefract; in 1937 he transferred to the same position with Baker Perkins Ltd., Peterborough; and in 1939 he joined I.C.I. (Explosives) Ltd., Stevenston.

During the Second World War he served with the Royal New Zealand Air Force and with the Royal Air Force, attaining the rank of squadron leader. On demobilization he served for a time with British Thomson-Houston, with Ferguson Pailin, Higher Openshaw, and with Metropolitan-Vickers Electrical Co., Manchester, before joining Associated Electrical Industries (India) Ltd., Calcutta, as planning engineer in charge of the industrial applications section of the engineering department. He left the company in 1950 to join Adamjee Jute Mills Ltd. as electrical engineer for their new jute mills in East Pakistan, where he spent three years. On returning to the United Kingdom in 1953 from Pakistan, he practised for a short time in a consulting capacity and then had a period oversea in Korea and subsequently in South India.

He is survived by his widow and two daughters of school age.

He joined The Institution as an Associate Member in 1951 and was elected a Member in 1954. R. L. C.

GEOFFREY PARR

Geoffrey Parr, who was technical director of Chapman and Hall, was born on the 29th December 1899 and died at his home in Winchmore Hill on the 30th May 1961.

He was educated at St. Anne's School, Redhill, and received his engineering training at Finsbury Technical College, being awarded its certificate in electrical engineering in 1917. He became a technical assistant at the Admiralty, Portsmouth, in 1918 and in 1919 went to the City and Guilds Technical College as a lecturer and demonstrator. In 1926 he joined the Edison Swan Electric Co., Ponders End, as a research engineer and in 1932 was placed in charge of its technical service department.

In 1941 he became editor of the newly founded journal *Electronic Engineering* and later managing editor. In 1949 he took his final position with Chapman and Hall, who had published his book 'The cathode-ray tube and its applications' in 1937. He was also a joint author of 'The technical writer', published in 1959. He lectured all over the country on technical writing and other subjects.

His deepest interest, apart from his family, was the Television Society, although he never seemed too busy to take an active part in other institutions. He helped on several committees of The Institution, with the Royal Institution, and as honorary secretary of the Electroencephalograph Society, of which he was a founder member.

He joined the Television Society in 1934 and in 1936 became honorary lecture secretary. In 1944 he became editor of its journal, increasing its quality and improving its circulation fourfold. In 1945 he became honorary secretary, and at the Society's Silver Jubilee Dinner in 1952 he was presented with a gold watch by the president, Sir Robert Renwick, on behalf of the members for 16 years' devoted service. He retired from this position only two weeks before his death.

He was a particularly cheery, kindly man, who was always ready to help others. As a result, it would indeed be difficult to find someone with a greater number of real friends. He will most certainly be very greatly missed, but the Television Society, whose resuscitation and expansion after the war were almost entirely due to him, is a memorial that he could well be proud to leave behind him.

He joined The Institution as a Student in 1919 and was elected a Graduate in 1925, an Associate Member in 1943 and a Member in 1947. He was awarded an Ambrose Fleming premium jointly with W. Grey Walter in 1943 for their paper entitled 'Amplifying and recording technique in electro-biology, with special reference to the electrical activity of the human brain'. O. S. P.

CHARLES ERNEST RICKARD

Charles Ernest Rickard, O.B.E., who died on the 11th May 1961 at the age of 80, was educated at East London Technical College and at University College London. He then joined the Wireless Telegraph and Signal Co. in 1898 as a technical assistant on G. Marconi's small personal staff. In the first Trinity House tests he served the usual month on the East Goodwin light vessel, maintaining radiocommunication with the South Foreland lighthouse; then in 1899 he had a period of watch-keeping and testing at the Needles station, Isle of Wight, communicating with Marconi's new laboratory at Sandbanks, Poole; then he went to the newly opened works to link up with Harwich by radio over 30 miles and for the first time all overland. Later in 1899 he accompanied Marconi to the United States for the first radio demonstration given to the American Navy between ships at sea. In 1902 he was again in New York, with Marconi, reporting the first International Yacht Race, employing a land station at Siasconset and Rickard on the Nantucket light vessel. While still on board he reported the arrival from Liverpool of the first Cunard vessels to be fitted with radio.

In 1903 he was in charge of radio ship-fitting for the Belgian Marconi Co. In 1904 he was appointed 'to experiment and advise the Chilean naval authorities regarding projected radio installations'. From 1906 to 1908 he was successively engineer-in-charge, inspector-general and technical adviser on radio to the Chilean Navy, with the rank of naval commander. In 1912 he was delegate plenipotentiary for Chile at the first International Radiotelephony Conference held in London. He installed and organized Chilean naval coastal, lighthouse and point-to-point radiotelephone services; inaugurated a Chilean radiotelephone school; and trained a technical staff. During the First World War he correlated reports on the movement of shipping from the whole of this vast radio network, stretching along a broken coastline of some 2500 miles, which was of considerable assistance to the British Admiralty, and for his services he was appointed an Officer of the Order of the British Empire in 1919.

Returning to England in 1919, he was appointed to assist the chief engineer, Marconi Co. In 1930 he spent a period in Russia, at that Government's request, to advise on radio matters. He was appointed engineer-in-chief, Marconi Co., in 1932 and general manager in 1941; he retired in 1946. So ended an outstanding career that helped to shape the technological and political outlook of his age.

He never married. He was keen on walking, golf, motoring, and gardening. His early hobbies included horology, heraldry, microscopy, music, radio and television.

For the last two years he was a house-bound cripple, living until the end under the devoted care of a surviving younger sister at Seaford, Kent.

He joined The Institution as a Member in 1921. He served as chairman of the Wireless Section in 1930–31 and was awarded a Wireless Section premium in 1931 for his chairman's address. His progress review entitled 'Radio telegraphy and radiotelephony' was published in the *Journal* in 1939. H. M. D.

MARSHALL DALE STONEHOUSE

Marshall Dale Stonehouse, M.B.E., who died suddenly at his home at Carshalton Beeches on the 15th May 1961 was born in Guernsey on the 5th May 1902. He was educated at Elizabeth College, Guernsey, and received his technical education part-time in Birmingham. He commenced his career in the electricity supply industry in 1922 with Poplar Borough Council, where he held the position of assistant shift engineer. In 1924 he became shift engineer with Wolverhampton Corporation and was promoted a year later to mains assistant. From 1927 to 1929 he worked as a district engineer in North Wales and then joined Electric Development and Securities Trust as assistant to the technical adviser. In 1948 he was appointed distribution liaison technical engineer to the British Electricity Authority, and he continued to hold this position under the Electricity Council when it was established in 1958.

He was very well known in electrical engineering circles in this country. He carried out a good deal of preparatory work on a minimum code of wiring practice and was closely associated with a large number of important bodies concerned with electricity supply matters, including many British Standard Institution committees of which he was a member. In the wider field he contributed towards the establishment and maintenance of good relations oversea, and on a number of occasions he represented the Electricity Council at international conferences at home and abroad.

Strength of will, firmness of purpose and a remarkably sound judgment were among the notable features of his character, and these, together with his kindness and sincerity, are perhaps the outstanding qualities for which he will be best remembered. He is survived by his widow, a son and a daughter.

He joined The Institution as a Student in 1923 and was elected an Associate Member in 1929 and a Member in 1946. He was appointed a Member of the Order of the British Empire in 1959. J. F. E.

SOME RECENT BOOKS

UNDERSTANDING ORGANIZATIONAL BEHAVIOR

C. ARGYRIS

LONDON: TAVISTOCK. 1961. 179 PP. 38s.

THIS book, by the Associate Professor of Industrial Administration, Yale University, is a substantial contribution to the field of scientific management, thought and research.

In the first chapter the author develops a theoretical framework that can be used to diagnose accurately the interrelations and variables of the complex organization. His main thesis is that organizations evolve from simple beginnings with one or two variables that fuse together and generate new variables that, in turn, generate new ones and so on. Knowing the properties of these variables, one can predict the results and products of their interaction. Thus there are two aspects of organization—genetic and dynamic. The author first selects a small number of variables, from which he begins to develop the genetic theory. He deals with the impact of the formal organization on the individual and the strategical aspects of organization and analyses the nature of organization in terms of eight propositions. From these a theoretical model of organization is constructed that provides the researcher with a list of probable relevant variables and their interrelations.

To fill the gap between theory and reality, the author, from experience and research, erects a series of guide-posts to assist in diagnosing organizational behaviour. Examples of basic guide-posts are (i) an organization is an arrangement of parts that form a unity or whole, which feeds back to help maintain the parts, (ii) a part of an organization is an organic part, in that it exists by virtue of its position in the pattern that is the whole, and (iii) the whole, in turn, differs from the parts, in that it has a different boundary to that of any given part, and the functional unity of the whole displays properties only revealed in the full operation of the whole.

In Chapter 2 the author presents procedures for those engaging in organizational research, such as the types of question to be asked, the strategy behind the questions, and the nature of the interview situation.

In Chapters 3 and 4 a model is given of Plant X, based on the framework and guide-posts. The model deals with the system and subsystems of Plant X and the parts that go to make up the system, such as the method of intake, the types of skill, job security, bonus systems, the reasons for dissatisfactions, etc. The interrelations of these parts and the mechanisms by which they create the whole are discussed. Predictions are made and tested about the impact of change.

Chapter 5 is probably the most interesting, for it contains the results of applying the hypotheses inferred from the Plant X model to predict the results of changes (due to new management controls) in Plant Y, which, until the changes were introduced, had a social system similar to that of Plant X.

In the final sections, the author studies some unanswered issues brought to light by his experiments and the practical value of the research. The value most frequently mentioned by top executives was that the model presented gave them a useful convenient map of a complex situation. Another value reported by management was that it gave them insight into *why* things occur as they do, e.g. high absenteeism, low turnover, lack of corporate spirit, etc. Above all, the model provided a 'realistic basis for executive development'.

There is little doubt that this work is a most important contribution to the understanding of organization. It has been produced at a most appropriate time, when British management is being criticized for its inability to think constructively, imaginatively and diagnostically. Management must learn to forecast accurately the possible effects of changes and to plan accordingly. Modern large complex organizations cannot be managed by rule-of-thumb or hunches, and this book will help the manager and executive to think and act in a scientific and diagnostic way. It will also be of the greatest help to the professional researcher. It is original and readable.

A. G. BEVERSTOCK

NUCLEAR PULSE SPECTROMETRY

R. L. CHASE

McGRAW-HILL. 1961. 221 PP. £3 6s.

THE precise measurement of nuclear-particle energy forms an essential part of most nuclear research; this book gives an excellent survey of the electronic pulse techniques developed for this purpose.

The author's introduction is a description of the pulse output characteristics from radiation detectors for energy measurement, together with suitable circuits for pulse integration, shaping and amplification by highly stable and linear pulse amplifiers.

Single-channel and multi-channel pulse-amplitude analysers are described, including the many forms of pulse-amplitude/digital-code convertor as well as the digital-storage methods of magnetostriction delay-lines, ferrite cores and cathode-ray-tube charge storage.

Pulse-time analysis for high- and low-energy neutron 'time-of-flight' measurement is well treated. There is a brief section on multidimensional analysers where simultaneous measurement on more than one nuclear particle is required; much more information on magnetic-tape storage systems should have been included here. The work concludes with a short account of counting-loss corrections for these instruments.

The author writes with authority, and the book is recommended as an excellent treatment of the subject. The techniques involved, although developed for nuclear work, have a much broader application to scientific measurement.

F. H. WELLS

ELECTRONIC, RADIO AND MICROWAVE PHYSICS

D. E. CLARK and H. J. MEAD

LONDON: HEYWOOD. 1961. 522 PP. £6 10S.

THE object of this book is to cover electronics, radio and microwaves for degree and diploma in technology examinations in physics. This is a very formidable task, and the authors have succeeded in producing a well balanced account of the subjects. Inevitably, most of the topics treated must be left at the stage when they just become interesting, and a quick survey of the material immediately provokes criticisms on the ground of omissions. This criticism is unjustified when the object of the work is borne in mind, the authors having provided an adequate foundation on which the student can build further knowledge.

The subjects treated include electromagnetic theory, transmission lines, waveguides, aerials, the properties of dielectrics and ferrites, thermionic valves, amplifiers, oscillators, microwave valves and noise. The only serious omission is that there is no mention of semiconductors or semiconductor devices. Emphasis is placed on the theoretical study of these topics; and, apart from a few minor errors, the treatment is clear. The chapters on oscillators and amplifiers are particularly good, containing more detail than is usual in a book at this level and indicating how practical requirements are met by circuit design.

One weakness lies in the inadequacy of the references. Most chapters have a few references, but in many cases these are far from comprehensive and omit the most important ones. Even more objectionable is that some of them, e.g. the C.V.D. reports listed in Chapter 14, are not available. This weakness reduces the value of the volume as a reference work.

J. BROWN

MAGNETIC TAPE INSTRUMENTATION

G. L. DAVIES

McGRAW-HILL. 1961. 263 PP. £3 3S.

THIS work is intended to cover the use of magnetic tape for data recording and scientific instrumentation work, as distinct from entertainment recording.

A preliminary introduction to the basic techniques and methods of tape magnetization is given, but this chapter could be a little misleading since digital-recording methods are not treated. A full and complete analysis of all recording methods then leads to a comparison of the various methods in terms of maximum-information-packing density per square inch of tape. A proper comparison is probably impossible, but this section could be improved by a more extensive discussion of accuracy in recording. The general problems of drop-out detection, parity and other recording errors also are inadequately treated.

The author fully describes tape-transport mechanisms and associated problems and rightly stresses that undue emphasis has been given to 'flutter' problems to the detriment of careful tape handling. The performance of transports in respect of 'flutter' and 'skew' is well covered, and electronic and mechanical methods are discussed. A good description of tape-head design, including flux reading heads, is provided, and some typical circuit designs of suitable recording-current generators and reading amplifiers are shown; these latter thermionic-valve circuits will soon be regarded as obsolete and be replaced by equivalent transistor circuits. The author ends with an account of a few applications and a brief review of magnetic-drum and disc storage in comparison with magnetic tape.

The book is well written, the author's descriptive style is easy to read, and the printing and presentation are excellent. It can be recommended as giving a good coverage of the subject, but in a few places the description, although correct, is somewhat superficial and the inquiring reader will need to refer to the quoted references.

F. H. WELLS

AN INTRODUCTION TO MACHINE TRANSLATION

E. DELAVENAY

THAMES AND HUDSON. 1960. 144 PP. 25S.

AT the time when the original French version of this volume was written, M. Delavenay was not an active worker in the field, and, for this reason, the book is less partisan than some of those written by experts with personal axes to grind.

There is a brief introduction, in which the impact of electronics on translation is discussed in general terms, and in which the essential differences between data-processing and translation are brought out. This is followed by a chapter that describes, rather badly, as much of digital-computer structure as is needed to understand how a machine can be programmed to translate. A historical account of 'm.t.' follows, and this leads to a discussion of the various problems and theories as they were seen two years ago. There is a practical example of a simulated machine translation, a glossary of terms, and a bibliography.

Numerous infidelities of translation, or proof reading, occur, but these do not seriously detract from the value of the book, which can be recommended as an excellent introduction to the subject.

A. D. BOOTH

PLASMA PHYSICS

J. E. DRUMMOND (*Editor*)

McGRAW-HILL. 1961. 386 PP. £4 17S.

THIS is an outgrowth of a series of seminars held at Stanford Research Institute. It covers basic plasma physics, magneto-hydrodynamics and microwave plasma physics, and each chapter is a separate article by an authority in the field.

Of the more general articles, two may be chosen for special mention in a short review: that by Klimontovich and Silin on 'The spectra of systems of interacting particles', which is a very able résumé of Russian work on the quantum theory of plasmas, and the survey of plasma research at the Massachusetts Institute of Technology by Prof. S. C. Brown.

Microwave aspects of plasma physics are interesting an increasing number of engineers, and two articles discuss a topic that has ramifications outside the bounds of plasma theory. This is the question of the physical differences between genuine amplified waves and those situations which might be interpreted by a moving observer as growing waves but which in reality are merely local disturbances fixed in space, for example evanescent fields at an obstacle in a waveguide. Sturrock discusses the question using only the dispersion equation, while Bunemann, adopting a more physical viewpoint, introduces the initial and final conditions. The articles on plasma power absorption and the plasma magnetron by the editor and on microwave diagnostics by Wharton are very useful.

The book contains material interesting to all research workers using plasmas and, in addition, to microwave-valve engineers. A less inclusive title would have given a fairer estimate of the contents. A. H. BECK

THE BUSINESS OF MANAGEMENT

R. FALK

PELICAN. 1961. 251 PP. 3S. 6D.

THIS is a further attempt first to analyse, and secondly to illustrate by example, what lies behind the post-war revolution in business management.

The author touches on the widest aspects of the subject, beginning with the concept of leadership as the source of policy and management as the necessary adjunct.

He deals in turn with personal qualities desirable in management, with organization, and with lines of communication and responsibility. A chapter is devoted to describing the syllabuses of courses that are available for training managers, together with the author's views on the emphasis that should be placed on example, experience and knowledge. The final chapters deal with examples of successful management in a number of well known firms, followed by fictitious case-histories of firms that have run into difficulties, and the reasons for their failure.

The book is readable, and obviously the writer is experienced in and knowledgeable of his subject. It should be of value to young people who begin to find themselves faced with management problems, especially in firms growing rapidly from small-scale operation into the realm of large business. C. DANNATT

COMPUTER LOGIC

I. FLORES

PRENTICE-HALL INTERNATIONAL. 1961. 458 PP. £2 5S.

FORTY per cent. of this book is devoted to the 'logic' of digital computers, this being the formulation and interrelation of the fundamental units of which they are made. These elementary functional units—to be distinguished from the actual electronic circuits and components—are combined according to prescribed logical rules to provide the operational features required in the computer. This section will be of value to those with general interest in this particular aspect of the functioning of computers and the interrelation of the memory, control and arithmetic parts of the machine. It is followed by a discussion of input–output mechanisms and the operator's controls and the logical interconnection of these with the central computer.

The rest purports to be a do-it-yourself guide to the design of digital computers—a whimsy that provides only an opportunity for a superficial review of many other aspects of the subject. A long glossary of computer terms and a bibliography (exclusively United States) are included. H. McG. ROSS

ELECTRONIC PACKAGING WITH RESIN

C. A. HARPER

McGRAW-HILL. 1961. 339 PP. £4 5S. 6D.

THIS is an excellent work, authoritative and full of useful information. Unfortunately, it is written entirely from the American point of view, and all European work is omitted. It would have been courteous to have credited the Swiss for the initial development of epoxy resin—one of the most widely used in America today. The resins referred to by U.S. trade names and numbers are not available in the United Kingdom, and a table giving European equivalents would have enhanced the value of the book considerably in other English-speaking countries.

Nevertheless, the text is comprehensive and covers all possible requirements for the user and potential user. As those who have worked with resins know, it is not possible just to 'pot' an equipment after it has been made—the entire design must be compatible with the embedding technique, a point that might have been brought out in the introduction. Data on lay-outs of components and compatibility of component finishes with resins would also have been useful.

Some interesting definitions are given in the volume that might well be considered in Great Britain. They are: embedding—complete encasement of assembly; encapsulating—coating applied to assembly; casting—assembly with mould removed after use; potting—assembly with mould retained permanently; and impregnating—liquid forced into interstices, then cured. Americanisms such as 'flexibilized' epoxy-resin systems become a little tedious when occurring 15 times on one page (93), but this is a small price to pay for the really valuable information provided. This is certainly the most comprehensive and detailed book yet written on 'embedding, encapsulating, casting and potting' techniques.

G. W. A. DUMMER

CASE STUDIES IN ELECTROMAGNETISM

H. A. HAUS and J. P. PENHUNE

JOHN WILEY. 1960. 336 PP. £2 12S.

THIS fairly expensive paperback consists of two parts, the first of which is a collection of solutions to selected problems in electromagnetism, and the second a collection of six experimental studies. The authors teach at the Massachusetts

Institute of Technology, and they have designed the book to be studied with the text 'Electromagnetic fields, energy and forces' by Fano, Chu and Adler, used in the M.I.T. basic course on that subject.

The authors' purpose is to provide the student with 'measured guidance' in solving field problems himself, both by analysis and by experiment. In brief, they wish, most commendably, to help the student to correlate mathematical theory with the essential physics of problems and thereby to develop proper understanding. The authors have set themselves a vital and valuable educational task. Let it be said at once that they have succeeded. Throughout Part I, which is by far the major part, about 70 problems in forces, vector analysis, static and time-varying fields, electromagnetic energy and power, sinusoidal steady-state solutions, and forces and energy in moving systems are dealt with. The treatment is straightforward, and the language is clear. Some of the problems are simple and others not so, but the more difficult ones are indicated by a star to enable the student to select and proceed according to his abilities.

The notation used is that of the parent volume of Fano, Chu and Adler, and the integration of the two books is very close. Equations taken from the parent volume are given their number in that volume, and constant reference is made to the work. While a reader of some experience would not necessarily require to have the parent volume available, it would certainly be a help, and practically an essential for the student. The description of a complex quantity as a complex scalar (given right at the start under explanation of notation) is confusing, especially when there are real vectors (in bold-face italic), complex vectors (bold-face roman), and complex quantities (a bar above or below a light-face letter), and 'some letters denoting a quantity that is obviously complex, such as the impedance Z, are used without a bar'. Throughout the text it is not surprising that there are a number of notational errors.

Part II does not quite come up to the standard of Part I. It is fairly modest in extent, and many teachers may find that they have developed similar experimental work to a greater degree than the author. However, the experimental studies contain interesting suggestions on analogues, skin effect, field and circuit theory and a simple electromechanical energy convertor using a solenoid and plunger.

The reviewer recommends this book only to students of more than average intellectual attainment. Most teachers will find it highly stimulating and so too will those research engineers occupied with basic studies. A. J. O. CRUICKSHANK

MAGNETRONS

K. HINKEL

PHILIPS TECHNICAL LIBRARY. LONDON: CLEAVER-HUME. 1961. 93 PP. 23S. 6D.

THE wartime development of magnetrons was so intensive as to be followed by a long period showing relatively little advance, except in practical aspects appropriate to commercial and more reliable military equipments. In recent years, recognition of its limitations as an oscillator of doubtful frequency stability has confined use of the magnetron to applications where low supply voltage and high conversion efficiency are more important than spectral purity. Attention has turned to the interesting backward-wave oscillator and amplifier derivatives, which tend to be classed as 'crossed-field devices' and do not come within the scope of this book.

Modestly, the author 'hopes that his little book will prove useful as an introduction . . . and as an aid to better understanding of the physical background of this kind of tube'. It is disappointing, however, to find only material that was well known by the mid-1940s, except perhaps for guarded reference to proprietary types of cathode.

Written from the viewpoint of a magnetron-design engineer, the text sketches the elementary theories of d.c. to r.f. energy conversion, electronic motions and slow-wave-transmission circuits. The reasons for difficulty with mode control are developed gradually throughout, but it should be pointed out that the methods finally inferred by the author are alone inadequate in most practical developments of pulsed valves. The final chapter gives the theory of accepted techniques of measuring and describing the operating characteristics and load-coupling effects. There is a tendency to manipulate the formulae rather than to demonstrate their origins, and only occasionally are there glimpses of physical insight. Apart from six photographs of valves and components, no details are given of practical methods of construction or of operating equipment.

The applications engineer with algebraic facility could use the book to gain some appreciation of the dilemmas of his valve-development colleagues; but the student might prefer the more lucid 1946 article, of similar length and content, by Fisk, Hagstrum and Hartman, to which reference is made.

R. DUNSMUIR

BOOLEAN ALGEBRA AND ITS APPLICATIONS

J. E. WHITESITT

READING, MASS.: ADDISON-WESLEY. 1961. 182 PP. £2 11S.

BOOKS on Boolean algebra have tended to be of two kinds: the quasi-popular and the specialist treatise for professional mathematicians. This new work, however, combines a refreshingly rigorous mathematical presentation with an engineering background.

There is a preliminary discussion of set theory, which is made the basis for a comprehensive presentation of Boolean algebra; both formal and intuitive approaches are described, the latter making considerable use of the Venn diagram. As a mathematical example of Boolean algebra there is a chapter that describes symbolic logic and the calculus of propositions, and this, although superficially mathematical, is of importance in the discussion of arithmetical circuits in computing.

The middle part of the text discusses engineering-design topics, from relay switches to combination locks and adding and subtracting circuits in digital computers. There is a final chapter on probabilistic aspects of Boolean algebra, with applications to conditional probability, which is assuming increasing importance in self-learning automata.

The volume may be unreservedly commended as a first-rate introduction to the subject. A. D. BOOTH

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publications can be obtained from the organizations concerned, except where otherwise stated in a footnote

BRITISH ELECTRICAL AND ALLIED INDUSTRIES RESEARCH ASSOCIATION

Report CL/T2 **Summary of proceedings at international symposium on electricity in the tropics** by M. E. Thompson. II—Generation, transmission and distribution of electricity. 21s., postage 6d.

AN international symposium on electricity in the tropics was held from the 28th to 30th May 1956 in Paris. Four general reports, based on 20 of the papers on the subject of generation, transmission and distribution, were written. This document is a summary of the four general reports, the discussion and a paper 'Electricity in the province of Angola'.

Report F/T195 **A basis for short-circuit ratings for paper-insulated lead-sheathed cables up to 11kV** (copper conductors: unscreened) by L. Gosland and R. G. Parr. 24s., postage 9d.

PUBLISHED as *Proceedings I.E.E.*, paper 3314S, June 1961 (**108A**, p. 183).

Report L/T394 **The resistance of sheet insulation to surface discharges—II** by J. H. Mason. 18s.

RECOMMENDATIONS are made for standard tests for classifying sheet insulation in respect of the degradation and breakdown by surface discharges. These tests are shown to give a reproducible classification both for thin sheet insulation and for laminates of 1–3 mm thickness. The resistance to discharges of various glass–cloth laminates with silicone, epoxy-resin, melamine and polyester impregnation has been compared at stresses between 30 and 100 kV/cm r.m.s. The effects of temperature and mechanical strain on the discharge resistance of both glass and paper laminates are briefly discussed. It is shown that, at stresses between 2 and 3 MV/cm, the life of 35 μm-thick polythene films is some four times greater when positive sinusoidal pulses are applied to the rod electrodes than with equal negative pulses.

COMITATO ELETTROTECHNICO ITALIANO

IV Congress international d'electrothermie—Vols. 1 and 2. Milan, 1961. 35 000 lira (two volumes)

THE congress, held at Stresa, Italy, from the 25th to 29th May 1959, was devoted to the theme: tendencies of electro-heat in the sphere of the evolution of the production and utilization of energy in general and electrical energy in particular. Vol. 1 contains the programme, a general report of the congress, the discussion and an index. Vol. 2 contains all the papers presented at the congress, printed in one of the three official languages (English, French and German), together with a summary in all three languages. The papers cover the whole field of electrical process heating.

ELECTRICITY COUNCIL

Utilisation research report no. 18 **A domestic-heating survey of England and Wales.** London, 1961. gratis

THE results of a sample survey of some 4500 domestic electricity consumers in England and Wales, carried out in the first quarter of 1960, are given in the report.

ELECTROCHEMICAL SOCIETY INC.

Semiconductor abstracts compiled by the Battelle Memorial Institute. John Wiley and Sons Ltd., London, 1961. £5 12s.

NEARLY 2000 abstracts are given. There is an author and a subject index.

ELSEVIER PUBLISHING COMPANY

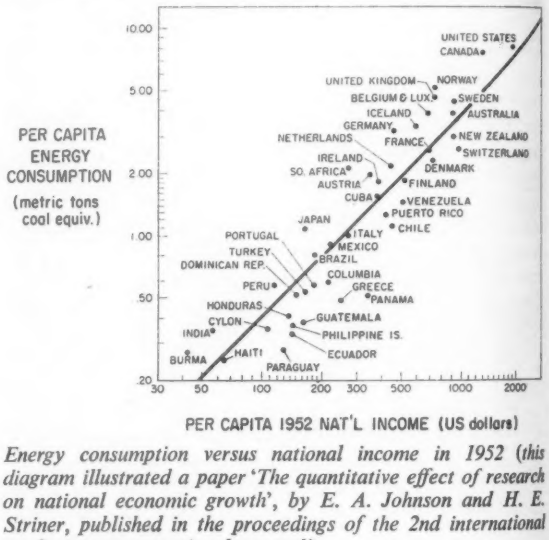
Electrostatic separation of mixed granular solids by O. C. Ralston. Amsterdam, 1961. 24s.*

THE introduction describes the electrostatic separating process. Various kinds of electrostatic separation, electrostatic-separator mechanisms, and applications and costs are also discussed.

ENGLISH UNIVERSITIES PRESS LTD.

Proceedings of the second international conference on operational research edited by J. Banbury and J. Maitland. London, 1961. £4 10s.

THE conference, organized by the International Federation of Operational Research Societies, was held at Aix-en-Provence, France, from the 5th to 9th September 1960. The proceedings were recorded in both English and French. If a paper is in English in the book, a résumé is given in French, and vice versa. Seven papers



Energy consumption versus national income in 1952 (this diagram illustrated a paper 'The quantitative effect of research on national economic growth', by E. A. Johnson and H. E. Striner, published in the proceedings of the 2nd international conference on operational research)

are on general topics and eight on particular fields of application, e.g. one paper is entitled 'The application of operational research methods to atomic and electric power'. Rapporteurs were appointed to record the discussions, and their reports are included in the book.

INTERNATIONAL ATOMIC ENERGY AGENCY

Safety series no. 6 **Regulations for the safe transport of radioactive materials.** Vienna, 1961. 9s.

THE regulations are intended to apply to the transport of radioactive materials by land, sea or air. The aim is to control and limit the irradiation and radioactive-contamination risks.

Safety series no. 4 **Safe operation of critical assemblies and research reactors.** Vienna, 1961. 9s.

MANY fields of information and experience are involved in the safe operation of critical assemblies and research reactors. Among the fields included in this manual are safety in design and

* Obtainable from D. Van Nostrand Co. Ltd., 358 Kensington High Street, London W.14

construction, the commissioning of critical assemblies and research reactors, staff training, qualifications and experience, and operational and experimental use of such equipment.

Review series no. 13 **Radiation-initiated polymerization and graft polymerization** by R. Roberts. Vienna, 1961. 6s.

THE mechanisms of polymerization initiated with high-energy radiation and the various methods for the production of non-random co-polymers are considered. An abstract is given in English, French, Russian and Spanish.

Review series no. 15 **Radioactive isotopes and their production under neutron irradiation** by N. E. Brezhneva and S. N. Oziraner. Vienna, 1961 (Russian/English). 6s.

THE production of radioactive isotopes in large quantities by neutron irradiation of various source materials in nuclear reactors is surveyed in this publication.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Publication 78 **Characteristic impedances and dimensions of radio-frequency coaxial cables.** 2nd edition. Geneva, 1961 (French/English). 6s. 9d.†

CHARACTERISTIC impedances and dimensions of r.f. coaxial cables are given in this publication. Test methods and details of construction are not discussed. The dielectric is not restricted to solid polythene as in the first edition.

Publication 81 **Tubular fluorescent lamps for general lighting service.** 2nd edition. Geneva, 1961 (French/English). 33s. 9d.†

TUBULAR fluorescent lamps with preheated cathodes for general lighting service operated from a.c. mains, with or without a starter, are covered by this publication. Included are technical requirements with which lamps must comply and the testing methods to be used for checking the quality and interchangeability of lamps.

Publication 126 **I.E.C. reference coupler for the measurement of hearing aids using earphones coupled to the ear by means of ear inserts.** Geneva, 1961 (French/English). 9s.†

A COUPLER is described for loading an earphone with a specified acoustic impedance when determining the physical performance characteristics in the range 200–5000 c/s of air-conduction hearing aids, using earphones coupled to the ear by means of ear inserts.

Publication 133 **Dimensions for pot-cores made of ferromagnetic oxides.** Geneva, 1961 (French/English). 6s. 9d.†

DIMENSIONS for pot-cores made of ferromagnetic oxides, and tolerances that are essential for ensuring interchangeability, are tabulated.

LIBRARY ASSOCIATION

Solar energy technology: 1954–1959 compiled by T. Brimelow. London, 1961. 3s. 6d.

THIS is an attempt to list all the significant literature on solar-energy technology published in Europe and the United States. There are 327 entries.

NUFFIELD FOUNDATION

Sixteenth report. Report for the year ended 31 March 1961. London, 1961. n.p.

GRANTS in the United Kingdom included a further one to the Nuffield Radio Astronomy Laboratories, Jodrell Bank (this time for £25000), a grant of £6700 to Birmingham College of Advanced Technology for research into sandwich courses for students studying for the Diploma in Technology, and a grant of £5500 to the Royal Technical College, Salford, for a research project concerned with mathematics in the electrical engineering industry.

In the Commonwealth, grants included one to the University of Sydney, Australia (£9600), for the design of radio-astronomy receiver systems, and one to the University of Melbourne, Australia (£850), for cosmic-ray research.

NATIONAL FOUNDATION FOR EDUCATIONAL RESEARCH IN ENGLAND AND WALES

Technical education abstracts from British sources, September–December, 1960. Vol. 1, no. 1. London, April 1961

THIS new quarterly contains abstracts for the use of those concerned with technical and further education. The annual subscription is £2 2s.

OXFORD UNIVERSITY PRESS

The Computing and Data Processing Society of Canada. 2nd Conference: June 6, 7, 1960. London, 1961. £2

THE papers in this book were presented at the 2nd conference of the Computing and Data Processing Society of Canada. The papers emphasize the areas of business data-processing and the engineering and scientific computing applications.

ROME AIR DEVELOPMENT CENTER

Biological effects of microwave radiation—Vol. 1 edited by Mary Fouse Peyton. Plenum Press, New York, 1961. $10

THIS is Vol. 1 of the proceedings of the 4th annual tri-Service conference on the biological effects of microwave radiation, held at the New York University Medical Center. Basic problems in measuring r.f. field strength, generation and detection of pulsed X-rays from microwave sources, and some engineering aspects of microwave-radiation hazards are discussed, as well as purely biological effects.

W. H. SANDERS (ELECTRONICS) LTD.

Experimental microwaves by A. W. Cross. Stevenage, 1960. 10s. 6d.

THIS book is divided into three chapters: waveguide action, the test bench, and measuring techniques. The treatment is not rigidly theoretical, but an attempt is made to show the reader what happens in a waveguide.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

Seventh annual report for the period 1st April 1960–31st March 1961. H.M.S.O., 1961. 5s.

PRODUCTION of fissile material, according to the report, was up to programme, and improvement in efficiency led to reductions in cost. The Calder and Chapelcross reactors produced more than 2000 million kWh for the Grid. Fuel elements were manufactured for the Bradwell and Berkeley reactors of the Central Electricity Generating Board, and also for the prototype advanced gas-cooled reactor at Windscale. The reactor-development programme is given.

The Authority's general research and development work is discussed, and the prospects of thermonuclear work are reviewed. A programme of seismological research bearing on the detection and identification of underground nuclear explosions has been started. Some of the fundamental research and development work of the Weapons Group is described.

UNITED STATES DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS

Monograph 30 **Corrected optical pyrometer readings** by D. E. Poland, J. W. Green and J. L. Margrave. Washington, 1961. 55 cents‡

THE table enables optical-pyrometer users to convert observed temperature to true temperature immediately, if the effective emissivity of the material being observed is known.

† Obtainable from the Sales Department, British Standards Institution, 2 Park Street, London W.1

‡ Obtainable from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

ADMIRALTY 621.3(076)

Examples in electrical calculations. 2nd edition

London: H.M.S.O., 1960. pp. xvi, 471. 21 × 14 cm. 20s.

Covers the requirements of students preparing for the preliminary- and intermediary-grade examinations of the City and Guilds Institute or the Ordinary National Certificate.

AMERICAN RADIO RELAY LEAGUE 621.39(03)

The radio amateur's handbook. 38th edition

West Hartford: American Radio Relay League, 1961. pp. 700. 24 × 16·5 cm. $4.50

BIBBERO, R. J. 413

Dictionary of automatic control

New York: Reinhold. London: Chapman and Hall, 1960. pp. xii, 282. 19 × 13 cm. £2 8s.

This is a dictionary arrangement of terms that have application in the literature of automatic control. The definitions are fairly full, and the work contains many cross-references. It is based on standards currently in use in the United States and on definitions given in *Automatic Control*, other periodicals, trade literature, etc. Reviewed in the February 1961 *Journal*, p. 114.

BIRKS J. B., and HART, J. (*Editors*) 537.226

Progress in dielectrics—Vol. 3*

London: Heywood, 1961. pp. vii, 292. 25 × 16 cm. £3 3s.

This third annual volume includes papers on dielectric waveguides and aerials, recent developments in cable insulation, and the theory of dielectric breakdown in solids. Reviewed in the July 1961 *Journal*, p. 458.

BRYANT, A. 93 : 06

Liquid history: to commemorate fifty years of the Port of London Authority, 1909–1959

London: published privately, 1960. pp. xvi, 84. 25 × 16 cm. n.p.

The interest of this story of the P.L.A. is increased by a brief account of the development of London River from the 14th to the 20th century.

CENTRE D'INFORMATION DU COBALT (*Editors*) 669.2

Cobalt monograph

Brussels: Centre d'Information du Cobalt, 1960. pp. xv, 515. 23·5 × 15·5 cm. 750 Belgian francs

This comprehensive work gives data on the cobalt industry and on the chemical and mechanical properties of the metal. It reviews present and potential applications for magnetic alloys, high-speed steels and other purposes.

CLARKE, N. (*Editor*) 53

A physics anthology*

London: Chapman and Hall. New York: Reinhold, 1960. pp. viii, 323. 22 × 14 cm. 35s.

A collection of interesting articles previously published in the *Bulletin of the Institute of Physics*, each the work of a well known author. There is no particular theme to the collection, which ranges over science and religion, Max Planck, education, hospital physics, engineering and technology. Reviewed in the January 1961 *Journal*, p. 42.

CROSS, A. W. 621.396.029.6

Experimental microwaves*

London: W. H. Sanders, 1961. pp. 213. 23 × 17cm. 10s. 6d.

The first part of this booklet describes in fundamental terms what happens in the waveguide; the second is a series of experiments to show the techniques used for measurement, together with a physical explanation of any necessary formulae used.

CROWHURST, N. H. 534.85

High fidelity sound engineering*

London: George Newnes, 1961. pp. viii, 328. 22 × 14·5 cm. £2 10s.

This book is intended to serve as an introduction to the basic principles of the subject and in particular to the basic designs of circuits and transducers. It does not include descriptions of actual equipment, which may soon become out of date. Control of the acoustics of the listening-room is dealt with in a short final chapter. Reviewed in the July 1961 *Journal*, p. 459.

DUKES, J. M. C. 621.3.049

Printed circuits: their design and application*

London: Macdonald, 1961. pp. xii, 228. 22 × 14 cm. £2

Describes the various manufacturing techniques used in the fabrication of printed wiring and circuits but is concerned mainly with the design of circuits and equipments to be produced by these techniques. It gives a considerable amount of practical data on the mechanical and electrical properties of the materials that are commonly used, and design data for the components and for strip transmission lines. The frequency range covered is up to 10 Gc/s. Reviewed in the July 1961 *Journal*, p. 460.

MENDELSSOHN, K. (*Editor*) 536.48

Progress in cryogenics—Vol. 3

London: Heywood, 1961. pp. vii, 173. 25·5 × 15·5cm. £2 5s.

This volume includes summarizing articles on low-temperature heat-exchangers, helium liquefiers, novel refrigeration cycles and devices, rocket propellants, and paramagnetic substances for nuclear orientation.

RALSTON, O. C. 621.359

Electrostatic separation of mixed granular solids*

London: D. van Nostrand, 1961. pp. viii, 262. 19 × 13cm. 24s.

Introductory chapters deal with electrostatic processes, after which specific types of mechanism are described. Applications are considered, together with costs.

SMITH, F. G. 621.396.9 : 523.1

Radio astronomy*

London: Penguin Books, 1960. pp. 264. 18 × 11cm. 7s. 6d.

This is a survey of the subject, in which the universe is considered in its familiar parts—the sun, the moon, the planets, our own galaxy, etc. There are chapters on radio-star surveys, radio cosmology, the ionosphere, and radio telescopes and receivers.

THOM, A., and APELT, C. J. 517

Field computations in engineering and physics

New York and London: D. Van Nostrand, 1961. pp. vii, 165. 23·5 × 15cm. 30s.

Deals with the method of squares, the relaxation technique, and other methods for the solution of partial differential equations.

VRIES, L. DE 413—30

English–German technical and engineering dictionary: supplement

Wiesbaden: Brandstetter-Verlag, 1959. pp. xxvii, 285. 23 × 15·5cm. £8 10s.

This supplement contains about 40000 terms relating to electrical engineering, machinery, commerce and manufacturing.

WALLIS, R. A. 697

Axial flow fans: design and practice*

London: George Newnes, 1961. pp. ix, 366. 22·5 × 14·5cm. £2 10s.

The detailed design information given in this book is based on modern aerodynamics studies.

The following elections and transfers approved by the Council of The Institution are effective from the 9th August 1961

ELECTIONS

Graduates

BEATTIE, George, B.SC.
BEAUMONT, Dennis Norman, B.SC.
BEIGHTON, Horace
BRIDGE, Peter Hugh, B.A.
BRITTAIN, Austin Furey, B.SC.(ENG.)
BROCK, Stuart, B.SC.
BROOKE, Brian Gordon
CLARK, Stanley Ross, B.A.SC.
COPPEN, Anthony Roland
GOFFIN, John Philip, B.E.
GOVINDASAMY, Shungmugam, DIP.TECH.(ENG.)
GRAHAM, Edward Christopher
HARDY, Leonard Ernest, B.SC.(ENG.)
HONEY, Denis William, B.ENG.
JOHNSTONE, Brian Edward, B.E.
KINDRED, Colin Ernest
KNOTT, Kenneth Francis, B.ENG.
MALBEC, Brian, B.SC.
OGUSLU, Izzet Necati
O'KEEFFE, Timothy Joseph, B.E.
PANDE, Harish Chandra, B.E., M.S.
PHILLIPS, Brian John, B.E.
PUGH, David John
RAHI, Mohammad Akatar
RANKIN, John Gillies
ROBERTS, John Edward, B.SC.
RUBIN, Olis Harold, B.SC.(ENG.)
SCHINDLER, James Terence, B.SC.(ENG.)
SHORTMAN, Brian Henry, B.SC.(ENG.)
SIDDIQUI, Jameel Yousuf
SLEATH, John Francis Adams, B.A.
SMITH, Peter Eric
STEMP, Graham Charles, B.SC.
TAPLEY, John Michael, B.SC.
THOMPSON, Alfred
TILLY, Derek William
WILSON, Geoffrey, B.ENG.
WITT, David Charles, M.A.

Students

ARNHEIM, George Walter
BAMJI, Pervez Jal, B.SC.
BASHAM, William Rutherford
BAXTER, Leslie James
BESANT, John Anthony
BINNIE, John Marshall
BOOTH, Bryan
BOWES, Peter John
BURGESS, David
BUTLER, James Robert Salisbury
CALLENDER, Anthony Clive John Christopher
CAVENOR, Michael Charles
COPE, Ernest
CRESSWELL, Peter Adrian
DENTU, Jacob Eliah Gyampo, B.SC.(E.E.)
FITCHEN, Peter William
FRY, Wilfred Archer
GARLICK, Michael John
GRAHAM, Andrew David
GRAINGER, William Alfred
GUNN, Norman Daniel Kerr
HADFIELD, Antony
HAINES, Graham Francis
HOLLOWAY, Harvey Frank
HUGHES, Austin
HUTSON, Ronald Barry
ISKANTO, Raden
JACKSON, Norman John
JAGATHCHANDRA, Kaluhara
JOHNSON, George Thomas
JONES, Richard Price
KUDRIMOTI, Shashikant Bhimsenrao, B.E., M.TECH.
KUNDI, Surinder Singh, B.SC.
KYIAMAH, Kaku
LAVERY, Robin Clay
LAWLESS, Kevin James
LOO, Kam Tye
MCDAVID, Colin Arncliffe
MAHMUD, Abdul Jalil, B.SC.
MIAN, Shaukat Ali, B.SC.(ENG.)
MYERS, John
OMWUASOANYA, John Ikeokw Ukaegbu
PARKER, John Claude
PAYNE, Robin Adney
PETERSON, Geoffrey Alexander
PRABHAKARAN, Kamisetty Pattabhi, B.E.
RAMACHANDRAN, Bhavani Lakshminarayanan
ROBERTS, Allan John
ROCHE, John, B.SC., M.SC.
SANDERS, Jeffrey Alan
SHAW, Winston Frederick
SMYTH, Thomas Steele
TAYLOR, Albert Victor
TURGOOSE, David
TURLEY, Alfred Joseph
WARBURTON, Harold
WARD, Gary John
WARRIOR, Richard
WASTIE, Hugh Malcolm
WEAVERS, Richard James
WHEAVER, John Barnes
WITHEY, Malcolm Edward
YOLLAND, Anthony Christopher

TRANSFERS

Student to Graduate

ASPDEN, Harry, B.SC.(TECH.)
BENTON, Dennis Albert, B.SC.(ENG.)
BOND, John William
BRIDGEMAN, Roger Geoffrey, B.SC.(ENG.)
BRIGGINSHAW, Bryan Alva
CAMPBELL, Keith David
CHAPMAN, Oliver Edmund
COVEY-CRUMP, Sub.-Lt. David John, B.SC.(ENG.), R.N.
CRISP, Richard James
CUNLIFFE, Juan Craine, B.SC.TECH.
DAVID, Joseph Haim Hakham, B.SC.(ENG.)

Elections and transfers

Student to Graduate (continued)

DIXCEE, Angus, B.SC.(ENG.)
DOBSON, Michael William
FREMONT, David de Mouilpied
GIDDY, John Harry, B.E.E.
HEYES, David Richard, B.SC.(ENG.)
HOLYOAKE, Lance
IONIDES, Rudolf Joannou, B.SC.
JACKMAN, David
JOHNSON, Hugh Basil Edwin, DIP.TECH.(ENG.)
JOLLY, Brian Stuart, B.SC.(ENG.)
KNIGHT, Ronald Walker, B.SC.TECH.
LEE, Edward John
MCFARLANE, Donald Miller, B.SC.
MATTHEWS, John Alister, B.SC.
MILLS, John Michael Francis, DIP.TECH.(ENG.)
MILNE, Peter Blair
PAGE, John Stephen, B.SC.(ENG.)
POSTANCE, Brian Victor, DIP.TECH.(ENG.)
ROBERTS, Eric
RUSSELL, Lawrence Victor
SAYER, George Edwin John, B.E.
SPRINGATE, David Henry Roland
STEELE, Colin
TOWLSON, Keith, B.SC.(ENG.)
UPHILL, Arthur John, B.SC.(ENG.)
WALKER, Fl.-Officer Robert Arthur, B.SC., R.A.F.
WHITECROSS, David Thomas
WOODCRAFT, John Lionel

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place, beginning at 5.30 p.m. (tea at 5 p.m.), except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a summary appeared in the *Journal* under 'The Journal digest: papers to be read', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card, which is available on request from the Secretary of The Institution

October 1961

O **5** *Thursday* G. S. C. LUCAS, O.B.E. Inaugural Address as President‡

MED **6** *Friday* G. MATTOCK, B.SC., PH.D., *and* G. R. TAYLOR, B.SC.(ENG.), will open a discussion on 'What is pH and its measurements?'* (at 6 p.m., tea at 5.30 p.m.)

M **10** *Tuesday* W. S. ELLIOTT, M.A. Chairman's Address‡

U **12** *Thursday* H. G. TAYLOR, D.SC.(ENG.). Chairman's Address 'Research in the field of electricity utilization'‡

ED **17** *Tuesday* P. D. AYLETT, PH.D., M.SC.(ENG.), will open a discussion on 'The place of digital computers in the teaching of electrical engineers'* (at 6 p.m., tea at 5.30 p.m.)

S **18** *Wednesday* J. S. FORREST, D.SC., M.A. Chairman's Address 'Research and transmission'‡

I **23** *Monday* PROF. A. TUSTIN, M.SC., will open a discussion on 'Is automation making satisfactory progress?'

M **24** *Tuesday* R. W. HOCKNEY, M.A., *and* T. O. JEFFRIES, M.A., D.PHIL. 'The use of analogue computers in predicting the space–time behaviour of nuclear reactors' (paper 3704M) *synopsis:* see p. 568

E **25** *Wednesday* R. J. HALSEY, C.M.G., B.SC.(ENG.), F.C.G.I. Chairman's Address 'Global communication'‡

O **26** *Thursday* P. M. J. AILLERET. Lecture on 'A comparison between generation and transmission problems in Great Britain and France'‡ (Joint Meeting with the British Section of the Société des Ingenieurs Civils de France)

* No advance information will be available and no Press report will be permitted
‡ No advance information will be available

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 9TH AUGUST 1961

	no. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	932	9742	12	1
£2 to <£5	2387	6596	8	10
under £2	31703	16706	4	0
		£48911	7	11

NOMINATIONS

B.S.I. TELECOMMUNICATIONS INDUSTRY STANDARDS COMMITTEE (TLE/–)

THE Council have nominated Mr. L. I. Farren, M.B.E., MEMBER, to serve as one of their representatives on the above committee in place of Mr. R. E. Robinson, MEMBER, who has resigned.

B.S.I. SUB-COMMITTEE TLE/8/2—ENVIRONMENTAL TESTING OF ELECTRONIC COMPONENTS AND EQUIPMENT

The Council have nominated Mr. A. C. Lynch, M.A., B.SC., MEMBER, to serve as their representative on the above sub-committee in place of Mr. K. A. F. Frost, B.SC.(ENG.), ASSOCIATE MEMBER, who has resigned.

NATIONAL COUNCIL FOR TECHNOLOGICAL AWARDS, BOARD OF STUDIES IN ENGINEERING

The Council have nominated Mr. S. E. Goodall, M.SC.(ENG.), PAST-PRESIDENT, and Mr. G. S. C. Lucas, O.B.E., VICE-PRESIDENT, to serve as their representatives on the above board.

WOOLWICH POLYTECHNIC, ADVISORY COMMITTEE FOR ELECTRICAL ENGINEERING AND TELECOMMUNICATIONS

The Council have nominated Dr. G. A. V. Sowter, B.SC.(ENG.), MEMBER, to serve as their representative on the above committee.

REGIONAL ADVISORY COUNCIL FOR TECHNOLOGICAL EDUCATION (LONDON AND HOME COUNTIES), ELECTRICAL ENGINEERING ADVISORY COMMITTEE

The Council have nominated Prof. M. W. Humphrey Davies, M.SC., MEMBER, and Mr. N. C. Stamford, M.SC.TECH., MEMBER, to serve as their representatives on the above committee.

BRISTOL COLLEGE OF SCIENCE AND TECHNOLOGY, BOARD OF GOVERNORS

The Council have nominated Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C., LL.D., B.SC., PRESIDENT, to serve as their representative on the above board.

KINGSTON TECHNICAL COLLEGE, GOVERNING BODY

The Council have nominated Dr. J. W. T. Walsh, O.B.E., M.A., MEMBER, to serve as their representative on the above governing body.

REGIONAL COUNCIL FOR FURTHER EDUCATION FOR THE SOUTH WEST. NORTHERN AREA AND SOUTHERN AREA ENGINEERING ADVISORY SUB-COMMITTEES

The Council have nominated Mr. G. Redfern, M.A., MEMBER (Northern Area), and Mr. S. G. Monk, M.SC.(ENG.), B.SC., MEMBER (Southern Area), to serve as their representatives on the above sub-committees.

NEWCASTLE COLLEGE OF FURTHER EDUCATION, GOVERNING BODY

The Council have nominated Mr. J. Christie, MEMBER, to serve as their representative on the above governing body.

MONMOUTHSHIRE EDUCATION COMMITTEE, TECHNICAL EDUCATION SUB-COMMITTEE

The Council have nominated Mr. W. Lloyd Williams, MEMBER, to serve as their representative on the above sub-committee.

PROGRAMME OF MEETINGS

SESSION 1961–62

THE programme card of London meetings for the first half of the session is being sent with this issue of the *Journal* to all members not residing within the area of a local Centre or Sub-Centre.

Any member living in the Provinces who often visits London, and is thus able to attend London meetings, may obtain a copy of the London card on application to the Secretary of The Institution.

FARADAY LECTURE, 1961–62

THE 1961–62 Faraday Lecture will be delivered by Mr. D. A. Barron, M.SC., MEMBER, his subject being 'Expanding horizons in communications'. Full details of the lecture tour are given below.

The primary object of the Faraday Lecture is to increase the interest of the general public in electrical matters, particularly those having an immediate bearing on the life of the community; **members are therefore asked to bring the Lecture to the notice of their friends.**

Admission is free by ticket obtainable as stated below; members are requested to enclose a stamped addressed envelope with each application. Tickets will not normally be issued earlier than one month before the date of the Lecture.

place	*date*	*address for tickets*
Bristol (Colston Hall)	21st November 1961	W. Dudley Morgan, c/o South Wales Switchgear Ltd., 86–88 Colston Street, Bristol 1

place	*date*	*address for tickets*
Cardiff (Sophia Gardens Pavilion)	23rd November 1961	D. Stephens, 7 Clovelly Crescent, Llanrumney, Cardiff
Birmingham (Town Hall)	2nd January 1962	J. C. Pyatt, Nechells 'B' Power Station, Nechells, Birmingham
Stoke on Trent (Hanley) (Victoria Hall)	4th January 1962	G. W. Pate, B.SC.(ENG.), 121 Rickerscote Road, Stafford
Nottingham (Albert Hall)	25th January 1962	J. Barnes, D.L.C., 'Quiet Ways', 13 Oakwell Drive, Ilkeston, Derbyshire
Sheffield (City Hall)	30th January 1962	C. B. Simpson, B.SC.TECH., c/o Yorkshire Electricity Board, No. 3 (Sheffield) Sub-Area, Commercial Street, Sheffield 1
Southampton (Guild Hall)	6th February 1962	H. V. Harley, B.SC., 72 Maylands Road, Bedhampton, Havant, Hants
London (Central Hall)	14th February 1962	The Secretary, The Institution of Electrical Engineers, Savoy Place, London W.C.2
Newcastle (City Hall)	20th February 1962	R. W. Shield, 'High Shieling', 152 Edge Hill, Darras Hall, Ponteland, Newcastle upon Tyne
Liverpool (Philharmonic Hall)	1st March 1962	B. F. Tickle, Pilkington Brothers Ltd., Research Laboratory, Lathom, Ormskirk, Lancs.
Belfast (Sir Wm. Whitla Hall, Queen's University)	7th March 1962	R. L. Marrs, B.SC., Gallaher Ltd., Virginia House, York Street, Belfast 15, N. Ireland
Glasgow (St. Andrew's Hall)	29th March 1962	D. R. Rollo, B.SC., c/o Bruce Peebles and Co. Ltd., 26 Blythswood Square, Glasgow C.2

THE INSTITUTION BUILDING

THOSE taking part in the Summer Meeting held in London from the 29th May to 2nd June 1961 were furnished with an illustrated booklet on 'The Institution building'. This deals in an introduction with the acquisition of the building in 1909, The Institution's growing need for improved accommodation, and the method finally decided on to satisfy this. Particulars are given of the alterations made during the course of the reconstruction scheme just completed, and notes are provided on the air-conditioning, lighting, speech-reinforcement and other facilities installed. The booklet also includes a reprint of a light-hearted article on 'The adventure of building', which was published in the December 1959 *Journal*.

Any member can obtain a copy of this booklet from the Secretary of The Institution.

NUCLEAR ELECTRONICS

A SYMPOSIUM on nuclear electronics will be held at Savoy Place on the 30th November and 1st December 1961. It is being organized by the Measurement and Control Section of The Institution, in conjunction with the B.N.E.C.

A conference on the same subject was held by the International Atomic Energy Agency at Belgrade in May 1961 and was attended by delegates from more than 30 countries. After consultation with the I.A.E.A., The Institution is arranging the forthcoming symposium to enable those who did not attend the Belgrade conference to hear and discuss reports on the material presented there.

The three sessions of the symposium will deal with radiation detectors, electronic circuits and techniques, and radiation monitors and instruments. At each session a report on the subject-matter of the relevant papers presented at Belgrade will be given, after which other speakers will either deal in more detail with subjects which they themselves described at Belgrade or give their own appraisal of the impact of the Belgrade conference on current researches in Britain. At the end of each session there will be an opportunity for the discussion of all the material presented.

A registration form for the symposium is enclosed with this issue of the *Journal*. The registration fee (which should accompany the registration form) is £1 for members of The Institution and £1 10s. for non-members. All registrants will receive a set of abstracts of the material to be presented.

DISCUSSIONS AT MEETINGS

THE Council of The Institution desire it to be understood that contributions to discussions at meetings should not be read from manuscript, since they consider that this form of presentation is contrary to the true spirit of a discussion.

THE SECRETARY OF THE INSTITUTION OF ELECTRICAL ENGINEERS

APPLICATIONS are invited for the appointment of Secretary of The Institution of Electrical Engineers, which will become effective in October 1962, and should be sent to the President of The Institution, Savoy Place, London W.C.2, marked on the top left-hand corner 'Secretaryship', to arrive not later than the 1st October 1961. Candidates should preferably be between the ages of 40 and 50 years and desirably be Corporate members of The Institution. There is an adequate superannuation scheme, and conditions of service and the salary will be commensurate with the high responsibility of the post, but not less than a basic figure of £4000. The selected candidate would be required to commence his service in June 1962 and work for three months in collaboration with the retiring Secretary.

WRITTEN CONTRIBUTIONS TO DISCUSSIONS

MEMBERS who are unable to be present at a meeting at which a paper is read, or who if present do not have an opportunity of speaking, may submit written contributions to the discussion, which will be considered for publication in the *Proceedings* of The Institution.

Written contributions on papers published in the *Proceedings* without being read at meetings will also be considered for publication.

Members should note that the Papers Committee have been obliged to set a limit of 300 words for contributions of either sort.

MEMBERS' GUESTS

MEMBERS are reminded that, under the Bye-laws of The Institution, every member (Students excepted) is entitled to introduce one visitor at each Ordinary Meeting. By direction of the Council, this applies also to all meetings of the Electronics and Communications, Measurement and Control, Supply, and Utilization Sections and to Informal Meetings.

STUDENTS' QUARTERLY JOURNAL

A PRINCIPAL article in the September 1961 issue of the *Students' Quarterly Journal* deals with missile control and guidance (J. A. Miller). Other articles discuss servos for trainable mountings (K. I. Bartlett), tunnel diodes (G. B. Smith), medical electronics (T. D. Cradduck), the r.t.f. system (A. J. Gulliver) and patents (D. F. Binns). D. R. Wilson writes on Russia in 1960, and there are articles on the North-Eastern Graduate and Student Section Golden Jubilee by A. C. Hall and the summer visit of the North-Eastern Section by R. G. Gold, as well as Section reports and book reviews.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

CORPORATE members and Graduates of The Institution in Canada and Mexico may now join the American Institute of Electrical Engineers without payment of entrance fee and without length of residence restrictions. At a recent meeting, the Board of Directors of the A.I.E.E. slightly modified their bye-law relating to admission privileges.

The bye-law now reads as follows:

'B.40.011d—ACCEPTANCE OF I.E.E. MEMBERS. A Corporate member or Graduate of The Institution of Electrical Engineers (Great Britain) in good standing is not required to pay an entrance fee for admission to an equivalent grade of membership in the American Institute of Electrical Engineers provided the applicant has taken up residence in the United States of America, Canada, or Mexico.'

MATHEMATICS—FRIEND OR FOE?

THE first annual lecture of the British Conference on Automation and Computation will be given in the Lecture Theatre at Savoy Place on the 27th September 1961 at 5.30 p.m. (tea at 5 p.m.). The lecturer will be Dr. D. G. Christopherson, O.B.E., F.R.S., Pro-Vice-Chancellor of the University of Durham and Warden of the Durham Colleges, who will speak on 'Mathematics—friend or foe?' The lecture is open to all members of the 31 member societies of B.C.A.C.

RADIATION PROTECTION

THE 5th advanced course on the principles of radiation protection will be held at the Harwell Reactor School from the 25th October 1961 to 30th January 1962.

The theoretical part of the course consists of about 110 lectures on basic scientific principles, principles of radiation protection, and general topics. Practical work covers between 15 and 20 experiments, and there is also a programme of visits.

Application forms and further details can be obtained from the Manager, Reactor School, Atomic Energy Research Establishment, Harwell, Berkshire.

OIL HYDRAULIC POWER TRANSMISSION AND CONTROL

THE Hydraulic Plant and Machinery Group of The Institution of Mechanical Engineers will hold a conference on oil hydraulic power transmission and control in the Main Meeting Hall at 1 Birdcage Walk, London S.W.1, on the 29th and 30th November 1961. Some 20 papers will be presented. Sessions will deal with pumps and motors, transmissions, servos and controls, and applications. Registration forms may be obtained from the Secretary of The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1.

VACUUM SCIENCE AND TECHNOLOGY

THE Institute of Physics and The Physical Society will hold a symposium on 'Some aspects of vacuum science and technology' at the Imperial College of Science and Technology, London, on the 5th January 1962. The symposium will cover (a) continuously exhausted bakeable vacuum apparatus for pressures below 10^{-9} mm Hg and (b) the controlled deposition of evaporated film.

Further details and application forms will be available about the end of October 1961 from the Administration Assistant, The Institute of Physics and The Physical Society, 47 Belgrave Square, London S.W.1.

HEAT TRANSFER

A CONFERENCE on international developments in heat transfer will be held at the Lecture Hall, Central Hall, Westminster, London S.W.1, from the 8th to 12th January 1962. It is being arranged by The Institution of Mechanical Engineers, The American Society of Mechanical Engineers, and The Institution of Chemical Engineers. The conference will deal with the fundamental aspects of heat transfer, and 124 papers will be presented. Some of these will be devoted to technology, and others will cover such fields as nuclear energy and aeronautical sciences. Aspects to be surveyed broadly are radiation, convective heat and mass transfer, condensation and boiling, and conduction and diffusion. The conference is a continuation of one held at Boulder, Colorado, U.S.A., from the 28th August to 1st September 1961.

A preliminary programme of the conference and registration forms may be obtained from the Secretary of The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London S.W.1.

TESTING OF PLASTICS

A CONFERENCE on 'Testing for performance', arranged by the Plastics Institute, will take place on the 13th–15th March 1962. The theme for the 13th March will be 'Testing for design'. On the 14th March, papers will be presented on the testing of electrical insulation for high-voltage application, the testing and evaluation of plastics for use as electrical insulation, and some pitfalls in dielectric testing. Other topics to be discussed at the conference are: testing for quality control, and the uses of statistical control methods.

Further information may be obtained from the Secretary, Plastics Institute, 6 Mandeville Place, London W.1.

CREEP AND FRACTURE

A JOINT international conference on creep and fracture will be held in New York from the 25th to 28th August 1963 and in London during October 1963. The sponsors are the American Society of Mechanical Engineers, The Institution of Mechanical Engineers and the American Society for Testing Materials. The conference will deal with the mechanical properties of engineering materials at elevated temperature. The emphasis will be on the use of creep and rupture information in the design of equipment for employment at high temperature.

Offers of papers from the United Kingdom, Africa, Asia, Australasia and Europe, with the exception of Japan and the Soviet Union, should be sent as soon as possible to the Secretary, The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1. An offer of a paper should be confirmed by a 250-word abstract before the 1st June 1962, and the manuscript will be required by the 1st December 1962. The proceedings of the conference will be published in English, but a manuscript may be submitted in any language.

INDUSTRIAL RESEARCH FELLOWSHIPS

A SCHEME of two-year fellowships is being introduced by J. Langham Thompson Ltd., under which young research workers will be appointed to carry out their research in the company's laboratories at Watford, Hertfordshire. Fellows will follow their own line of research within certain broad fields determined by the activities of the company. A panel of university consultants will give guidance on the running of the scheme, and the financial grants during the period of tenure will be such as to be attractive to the highest scientific talent in age groups up to approximately 30 years.

The fields of interest of the company include: solid state, cybernetics, logical systems, electronics, circuit techniques, microwaves, mechanics of solids, transducer techniques, and optics. Candidates for these fellowships will probably already have completed a higher-degree course. However, it is more important that they should be able to give evidence of original research of a high standard. Further information may be obtained from J. Langham Thompson Ltd., 176 High Road, Bushey Heath, Hertfordshire.

I.F.A.C. CONGRESS 1963

THE second congress of the International Federation of Automatic Control (I.F.A.C.) will be held, at the invitation of the Swiss Association for Automatic Control, at Basel, Switzerland, in September 1963. A committee of the British Conference on Automation and Computation is to co-ordinate the submission of papers for the congress from the United Kingdom.

It is expected that most of the papers will deal with the theory or application of automatic control, while a number will discuss the components of control devices. Theoretical subjects to be covered are: discrete systems, stochastic systems, optimal systems, learning systems, and systems reliability. In the applications field, anticipated topics are: process dynamics; computer studies of applications, on or off line; and optimizing or adaptive control applications. Components aspects to be described include: new and effective devices, and the measurement of the reliability of components.

Papers may be submitted in English, Russian, French or German. The final version of any paper by a United Kingdom author should reach the Honorary Secretary, B.C.A.C., c/o The Institution of Electrical Engineers, Savoy Place, London W.C.2, not later than the 1st June 1962, for transmission to the International Selection Committee of I.F.A.C. during August 1962.

General inquiries concerning the congress arrangements should be made to the Secretary of I.F.A.C., Dr.-Ing. G. Ruppel, Prinz-Georg-Strasse 79, Dusseldorf, Germany.

GEOMAGNETIC CONFERENCE AND U.R.S.I.–I.R.E. MEETING

A CONFERENCE on telluric and geomagnetic field variations, sponsored by the Union Radio Scientifique Internationale, the University of Texas and the United States Office of Naval Research, will be held on the 20th–21st October 1961. The conference is primarily concerned with geomagnetic and telluric phenomena in the frequency range 0·001–30c/s.

The following Professional Groups of the Institute of Radio Engineers are sponsoring a U.R.S.I.–I.R.E. meeting from the 23rd to 25th October 1961: Antennas and Propagation, Circuit Theory, Information Theory, Instrumentation, and Microwave Theory and Techniques.

The conference and the meeting will both be held at the University of Texas Student Union Building. Further information can be obtained from A. W. Straiton, P.O. Box 8026, University Station, Austin 12, Texas, U.S.A.

OVERSEA ATTENDANCE REGISTER

DURING the period 17th July to 16th August 1961, these members called at the Institution building and signed the Attendance Register of Oversea Members:

AIKEN, R. G. (Lower Hutt, New Zealand)
ALI, S. M. (Basra, 'Iraq)
APPLEBY, J. H. (Caracas, Venezuela)
APPS, G. J. (Salisbury, S. Rhodesia)
BATESON, A. (Nairobi, Kenya)
CALLANAN, R. R. (Sasolburg, S. Africa)
CARLILE, W. E. H. (Lagos)
DALTON, O. (Portland, Oregon, U.S.A.)
ELLIOTT, T. W. (Pretoria, S. Africa)
HORT, E. P. (Worcester, Cape Province, S. Africa)
HUMPHREY, F. J. (Vancouver)
JOSEPHIDES, T. S. (Kypseli, Athens)
LABROOY, C. H. J. (Ipoh, Malaya)
METCALFE, J. (Brisbane)
MORRIS, S. J. (Hamilton, New Zealand)
O'NEILL, P. J. (Klang, Malaya)
PARRIS, L. F. (Salisbury, S. Rhodesia)
THRELFALL, A. J. C. (Hong Kong)
VIVEGANATHAN, P. (Colombo)
WATSON, F. V. V. (Colombo)
WOODFALL, D. (Mexico City)
WRIGLEY, F. R. C. (Port-of-Spain, Trinidad)

News from abroad

WESTERN AUSTRALIA OVERSEA COMMITTEE

1961 activities

THE Committee have arranged three meetings so far in 1961. All have been held at the Electrical Engineering School of the University of Western Australia.

At the first meeting, on the 21st April, Dr. John Fall presented a paper 'Digital computers and their engineering application'. Dr. Fall gave a very interesting word-picture of the operation of digital computers, discussed the various types available, and described the various techniques used to record, store and handle the information.

On the 19th May, Mr. F. W. Dawson spoke on 'The satellite tracking station at Muchea'. Mr. Dawson is Station Manager and Principal Experimental Officer at Muchea, about 100 miles north of Perth. He explained that this tracking station was being installed by the United States in association with their man-in-space programme—Project Mercury. Mr. Dawson impressed his hearers with his knowledge, not only of the facilities and equipment that are installed at Muchea, but also of the theory of orbital and sub-orbital flight.

Immunity claimed

Mr. R. R. Lake spoke on 'The work of the Standards Association of Australia' at the meeting on the 16th June. Standardization, it appeared, had been going on for many centuries. Members were interested to hear of a Chinese emperor engineer (responsible, among other works, for the building of the Great Wall of China) who set about his work by beheading the scholars of the country before getting down to the practical details of engineering. University staff members present immediately claimed immunity under their professional-engineering status.

Meetings to come

A full programme is planned for the balance of 1961, involving four meetings, which include a joint meeting with the Perth Division of the Institution of Engineers (Australia).

R. R. L.

BULLETIN OF THE SECTIONS

UTILIZATION

ELECTRIC TRACTION

THE Annual Lecture of the Section was delivered at Savoy Place on the 25th May 1961 by Mr. J. A. Broughall, who took as his subject 'Electric traction'. The Section was honoured by the attendance of the President on this occasion.

To demonstrate the substantial part that electric traction plays in the modernization plan of British Railways and to show that part in proportion, an interesting film was first shown, which emphasized how every department of the railway is concerned in this effort to make the railways better fitted to perform their function in the life of the community. The lecturer observed that, while he believed the electric-traction engineer had no mean part to play in the British Railways of the future, it was not essentially the leading role. An article based on the lecture will appear in a future issue of the *Journal*.

He pointed out that, with the abolition of steam, the motive power of the future was to be a combination of Diesels and electric traction and, in comparing their respective merits, stressed the fact that the latter method avoided the restriction of engine power of a self-contained prime mover and gave that little extra that led to the fast, punctual and reliable trains that the public required. Mr. Broughall expressed this aspect of the matter succinctly by saying that, as to the power that could be made available by electric traction, 'you can have as much as you like, provided that you are prepared to pay for it'.

Conversion to a.c. system

As regards the advances that had been made in the power/weight ratio, the lecturer said that the weight of equipment was now about one-quarter of what it had been 40 years ago. Reasons were given for the decision to adopt the 25 kV, 50 c/s, single-phase system in place of the 1500 V d.c. system that had been the recommended standard up to the announcement of the modernization plan. A large amount of diversity had been permitted in the equipment of the original locomotives, so as to obtain experience on which future designs might be soundly based.

With respect to multiple-unit trains, some interesting details were given regarding the conversion of the 1500 V d.c.

overhead system in the Eastern Region to 6·25kV a.c. working. The automatic scheme was described that is used for changing from 25 to 6·25kV and vice versa en route, necessitated by clearance difficulties for the higher voltage in the immediate neighbourhood of cities served by the new electrification.

Mr. Broughall mentioned the extent to which the 50c/s system is being developed oversea and expressed his faith regarding its export possibilities.

Mr. T. E. Houghton very aptly voiced the thanks of the meeting to the lecturer by saying that they had listened to 'an excellent dissertation by an acknowledged authority', which was supported by Dr. W. G. Thompson, together with considerable acclamation. R. H. R.

DATA TRANSMISSION

ON the 26th April 1961, with Mr. T. B. D. Terroni in the Chair, Messrs. R. H. Franklin and J. Rhodes presented a most interesting lecture entitled 'Data transmission' at Savoy Place. An article based on the lecture will appear in a forthcoming issue of the *Journal*.

The lecture was a broad survey of the problem of transmitting digital information, particularly over existing telegraph and telephone circuits. A great deal of effort had been expended on making the public and private wire network as fault-free as possible in respect of the services it was planned to carry; data transmission, now in its infancy for commercial purposes but likely to grow rapidly, had brought many new problems. These could not be solved economically by making circuits completely error-free, and some form of error control was essential.

Error-detecting codes, requiring a repeat transmission, were likely to find a wider application than error-correcting codes, having less redundancy and better over-all transmission efficiency. The telex network was immediately suitable for 50bits/sec; 1200 and 600bits/sec were practicable over private-telephone wires and the public-telephone network, respectively; up to 500000bits/sec appeared practicable on a 1Mc/s circuit, and this might find application for remote control of computers.

Computers and data-processing

The discussion, opened by Mr. E. P. G. Wright, was both extensive and animated. It centred largely on requirements of computers and data-processing systems. As computers increased in size, their usefulness increased sharply; Mr. H. McGregor Ross suggested a cube law. It seemed generally agreed that we were now entering a new phase of computer development along these lines, which involved teleprocessing. Discussion also covered the best method of modulation; Mr. K. L. Smith stated that phase modulation showed an advantage over frequency modulation of 5dB in the presence of white noise. The authors' replies to the discussion were both competent and amusing. R. J. H.

VISIT TO HARWELL

A VISIT to Harwell always attracts many visitors, and the day visit on the 29th April 1961 proved no exception, since 140 members and their ladies participated. True, only members were allowed to visit the Atomic Energy Research Establishment, but, after the ladies had toured some Oxford colleges, they were reunited with their menfolk for an excellent lunch at the Establishment, at which they were delighted to have as their guests Sir William Penney, Deputy Chairman of the United Kingdom Atomic Energy Authority, and Lady Penney.

Excellent choice

But back to the morning: the members, after coffee during which most helpful talks were given by Mr. R. F. Jackson and Mr. M. J. Marchbanks, proceeded to see work associated with controlled thermonuclear research, either Dido or Pluto, and Nimrod. Bearing in mind that the Establishment has become one of the outstanding research laboratories in the United Kingdom and the large extent of the work in progress, it was thought, quite rightly, that these projects possessed the maximum interest for members.

Despite the excellent choice, time was all too short for fully examining the work and the helpful demonstrations that had been arranged in the controlled-thermonuclear-research laboratories. Much of the work was directed towards determining the physical conditions existing in the plasma, together with methods of heating and confining it.

The sequence of inspection of the projects for all parties did not follow the order set out above, but all were inspected, except that only one of the high-flux reactor buildings (either Dido or Pluto) was toured. These heavy-water-moderated and -cooled reactors used a uranium–aluminium alloy fuel and were engaged only on irradiation experiments. Heat-exchangers, accepting the heavy water, heat ordinary water, which was passed to conventional cooling towers, where several megawatts were dissipated. Although a sense of quiet pervaded within, the operators were obviously efficiently handling the reactor, with its multiplicity of experiments, accessories and instruments.

The site occupied an area roughly one mile long by half-mile wide, and, in their journeyings by bus about the Establishment, members were given glimpses of other buildings, including long flight tubes associated with the neutron project.

Possibly on reaching Nimrod—'A mighty one in the Earth'—the supply engineers were in phase, since the size of the buildings and the 7GeV proton synchrotron, with its 7000 tons of 150ft ring-shaped magnet, assumed customary proportions. Nevertheless, the immensity of the undertaking

Cruising down the river . . . to Caversham

and its engineering problems could not fail to excite the imagination. The work that is to follow its completion in 1962 will undoubtedly advance Britain's part in research in nuclear science.

Thames Valley

At lunch, Mr. J. E. L. Robinson, Chairman, expressed to the A.E.R.E. staff the appreciation of the Section for making the visit so full of interest and memorable. Afterwards the party was conveyed to Wallingford. From contact with the future of science, acquaintance was renewed with the timeless atmosphere of the Thames Valley. Gently carried downstream past the many delightful views, associated with place names such as Goring, Pangbourne and Mapledurham, under cool but not unpleasant skies, the visitors reached Caversham. Disembarking, they went their various ways to remember an interesting and pleasant day. F. C. W.

News from the Centres

MERSEY AND NORTH WALES CENTRE

Summer Visit

THE annual Summer Visit took place on Saturday, 27th May 1961, when members and their ladies travelled by coaches to Lake Vyrnwy, set in the unsurpassed beauty of Wales. Before departure from Liverpool, detailed notes of the historical and technical features of the Vyrnwy-reservoir scheme were handed to each of the party by Mr. J. H. T. Stilgoe, Water Engineer to the Liverpool Corporation. It was by Mr. Stilgoe's co-operation that the visit had been made possible.

Submerged village

The route lay via the Mersey Tunnel through Chester and Oswestry (for morning refreshment) to the village of Llanwddyn—after Saint Wddyn—constructed below the dam to replace the village that was submerged. Lunch was taken here in the community centre, when we were joined by Mr. H. Howard, the site engineer, our host and guide for the afternoon. Mr. D. A. Picken addressed our thanks to Mr. Howard. Then followed a 12mile tour of Lake Vyrnwy, taking in an inspection of the straining tower with its screens and of the hydroelectric plant at the dam. This installation registers the rate of discharge of compensation water that serves to operate the turbine.

Leaving Vyrnwy we passed through picturesque Llangollen to Rhostyllen, where Mr. R. N. Pegg, who had taken part in the day's activities, assumed the role of host on behalf of the Merseyside and North Wales Electricity Board.

In addition to the meal that awaited us, variety entertainment was provided by members of the staff under their producer, Mr. Emyr James. Choral selections by the Glee Club reached a very high standard and well merited Mr. Picken's laudatory comments in expressing our appreciation.

Annual golf tournament

This event was held on Tuesday, 20th June 1961, on the course of our good friends, the Southport and Ainsdale Golf Club. Mr. John Collins, playing off a handicap of 22, no doubt for the last time, won the G. P. Dennis Challenge Trophy and the Singles competition, handicap 14 and over. Other winners were Mr. A. Josey, Singles under 13, and the Greensome, Messrs. R. S. Owen and W. Rothery.

Mr. Picken, in the dual capacity of Chairman and Honorary Benevolent Fund Treasurer, presented the prizes. Mr. G. L. Simpson, who organized the tournament, just missed further distinction, as he was runner-up in two of the events.

Annual Dinner

The Annual Dinner is to be held at the Grosvenor Hotel, Chester, on Monday, 6th November 1961. E. W. A.

The prize-winners at the golf tournament